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THE BRITISH SOCIETY FOR THE PROMOTION
OF VEGETABLE RESEARCH

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Twelfth
Annual Report
1961

(OCT. 1960 - SEPT. 1961)

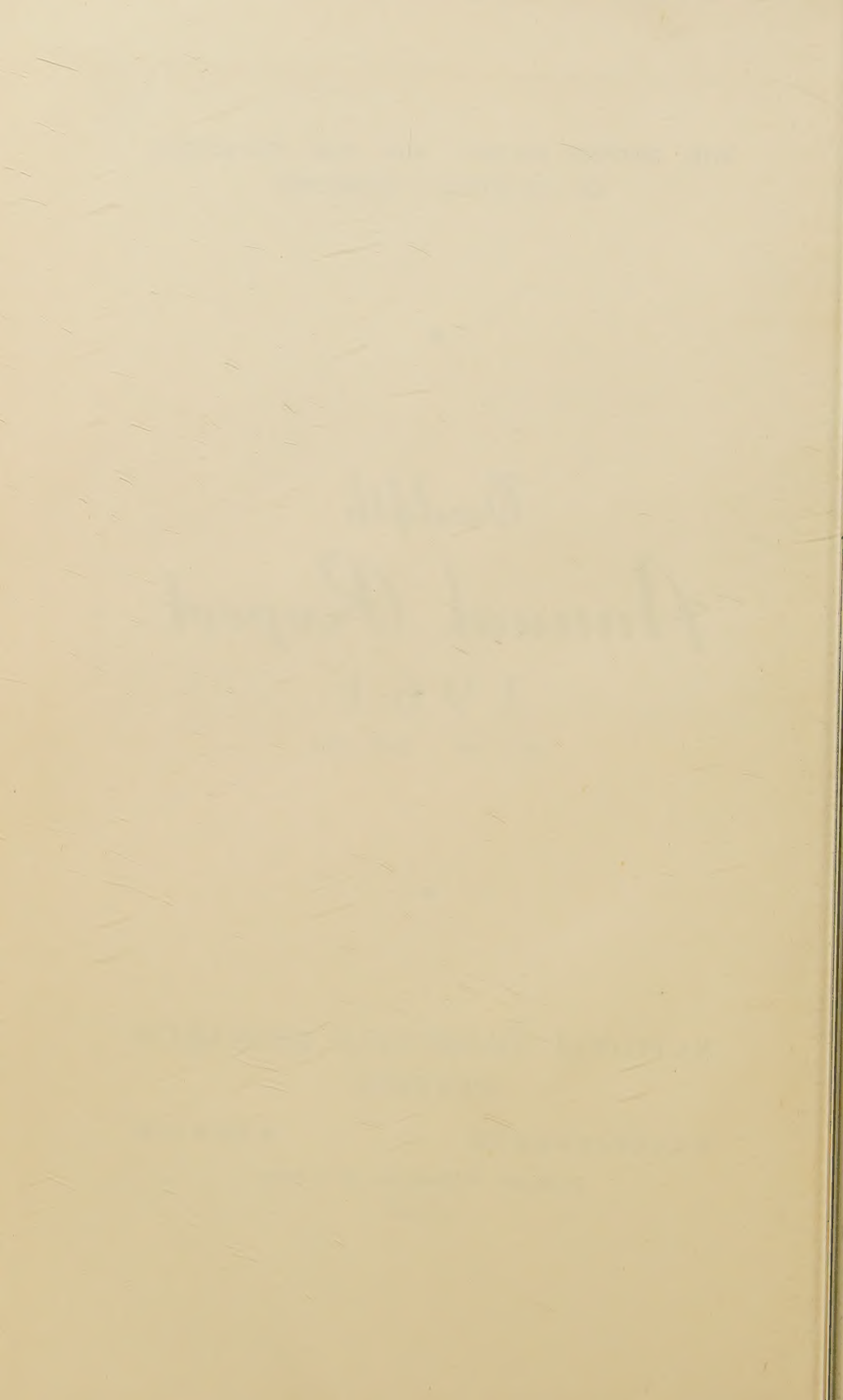
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NATIONAL VEGETABLE RESEARCH
STATION

WELLESBOURNE - - WARWICK

Telephone : Wellesbourne 382 (3 lines)

1962



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THE CONSTITUTION OF THE NATIONAL VEGETABLE RESEARCH STATION

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a Governing Body incorporated on 28th September 1949, as a company limited by guarantee, not having a share capital, and having the title 'The British Society for the Promotion of Vegetable Research', with its registered office at Wellesbourne.

The members of the Governing Body, twenty-three in number, include nominees of the Lord President of the Council and of the two Agricultural Departments of Great Britain, of the Department of Scientific and Industrial Research, of various learned societies, universities and institutions concerned with horticulture, of vegetable producers (through the National Farmers' Unions of the two countries and the National Allotments and Gardens Society) and of trade interests.

The properties at Wellesbourne and Paglesham are leased to the Society by the Agricultural Research Council (A.R.C.). Until 31st March 1956, the Society depended for its funds on grants from the Ministry of Agriculture, Fisheries and Food who were advised by the A.R.C. regarding research work and staff. On 1st April 1956, the grant-aiding functions of the Ministry were transferred to the A.R.C.

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Lord President of the Council, the Minister of Agriculture, Fisheries and Food, and the Secretary of State for Scotland:

Professor K. MATHER, C.B.E., D.Sc., F.R.S., Department of Genetics,
The University, Edgbaston, Birmingham, 15.

W. J. F. SOPER, Esq., J.P., New Hall Farm, Harlow, Essex.

Professor M. STACEY, Ph.D., D.Sc., F.R.S., Department of Chemistry,
The University, Edgbaston, Birmingham, 15.

Principal M. A. H. TINCKER, M.A., D.Sc., F.C.S., F.L.S., F.R.S.E.,
The North of Scotland College of Agriculture, 41½ Union Street, Aberdeen.

Professor C. W. WARDLAW, M.Sc., Ph.D., D.Sc., D.Sc. (McGill), F.L.S., F.R.S.E.,
Department of Botany, The University, Manchester, 13.

Appointed by the Department of Scientific and Industrial Research:

R. G. TOMKINS, Esq., M.A., Ph.D., Ditton Laboratory, Larkfield, Maidstone, Kent.
(Until 27/9/1961).

Appointed by the University of London:

Professor H. W. Miles, Ph.D., D.Sc., Wye College, (University of London), Ashford, Kent.

Appointed by the University of Reading:

Professor O. V. S. HEATH, D.Sc., F.R.S., Department of Horticulture,
The University, Reading, Berks.

Appointed by the University of Cambridge:

J. BARKER, Esq., M.A., PhD., F.R.S., The Botany School, Downing Street, Cambridge.

Appointed by the University of Bristol:

Professor H. G. H. KEARNS, O.B.E., B.Sc., Ph.D., Dip. Agric., University of Bristol,
Department of Agriculture and Horticulture, Research Station, Long Ashton,
Bristol.

Appointed by the University of Edinburgh:

ALEXANDER NELSON, Esq., Ph.D., D.Sc., F.R.S.E.,
University Department of Botany, at Royal Botanic Garden, Edinburgh, 3.

Appointed by the Royal Society:

Professor W. BROWN, M.A., D.Sc., F.R.S., The Bush, Haddenham, Aylesbury, Bucks.

Appointed by the John Innes Institute:

K. S. DODDS, Esq., Ph.D., D.Sc., Bayfordbury, Herts.

Appointed by the National Farmers' Union:

F. M. BARDSLEY, Esq., Low Mill Farm, East Ayton, Scarborough, Yorks.

R. FORD, Esq., Began Farm, St. Mellons, Cardiff, Glamorgan.

G. G. HOLE, Esq., Pakyns, Hurstpierpoint, Sussex.

J. LAITY, Esq., Polkinghorne, Gwinear, Hayle, Cornwall.

W. F. SWIFT, Esq., Avon Cottage, Fladbury, Pershore, Worcs.

Appointed by the National Farmers' Union of Scotland:

DAVID LOWE, Esq., C.B.E., F.R.S.E., Elvingston, Gladsmuir, East Lothian. (Chairman).

Appointed by the Horticultural Trades' Association:

J. S. W. CRACKNELL, Esq., O.B.E., V.M.H.,
'Glenhurst', Arbor Lane, Winnersh, Wokingham, Berks.

Appointed by the Royal Horticultural Society:

Professor T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S.,
'Redwings', Old Church Road, Nailsea, Somerset.

Appointed by the National Allotments and Gardens Society:

Professor J. CALDWELL, Ph.D., D.Sc., Hatherly Biological Laboratories,
Prince of Wales Road, Exeter.

Appointed by the Seed Trade Association of the United Kingdom:

F. HOLL, Esq., Harrison and Sons (Leicester) Ltd., St. James' Street, Leicester.

The Executive Committee

Professor W. BROWN
J. S. W. CRACKNELL, Esq.
Professor O. V. S. HEATH
G. G. HOLE, Esq.
J. LAITY, Esq.

DAVID LOWE, Esq.
Professor K. MATHER
W. F. SWIFT, Esq.
Professor T. WALLACE (Chairman)
Professor C. W. WARDLAW

Staff and Research Sub-Committee

Professor W. BROWN (Chairman)
J. S. W. CRACKNELL, Esq.
R. FORD, Esq.
Professor O. V. S. HEATH
Professor H. G. H. KEARNS

DAVID LOWE, Esq.
Professor K. MATHER
W. J. F. SOPER, Esq.
Dr. R. G. TOMKINS
Professor T. WALLACE

Co-opted:

C. E. HUDSON, Esq., C.B.E., N.D.H., V.M.H., Ministry of Agriculture, Fisheries and Food,
Great Westminster House, Horseferry Road, London, S.W.1.

Farm Management Sub-Committee

F. M. BARDSLEY, Esq.
G. G. HOLE, Esq.
F. HOLL, Esq.

J. LAITY, Esq.
W. J. F. SOPER, Esq.
W. F. SWIFT, Esq. (Chairman)

Co-opted:

F. H. VANSTONE, Esq., B.Sc., Ph.D., A.Inst.P., Head of Horticultural Engineering
Department, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds.

Varieties Inspection Sub-Committee

J. S. W. CRACKNELL, Esq.
DAVID LOWE, Esq. (Chairman)
G. G. HOLE, Esq.

F. HOLL, Esq.
W. F. SWIFT, Esq.

Co-opted:

C. D. R. DAWSON, Esq., Ph.D., A. L. Tozer Ltd., Pyports, Cobham, Surrey.
F. G. POTTER, Esq., A.H., R.H.S., Sutton and Sons Ltd., The Royal Seed Establishment,
Reading, Berks.
L. A. W. PRIOR, Esq., W. Deal and Sons Ltd., Kelvedon, Essex.

STAFF

Director:

JAMES PHILP, B.Sc. (Glas.), Ph.D. (Lond.).*

Deputy Director:

D. W. WRIGHT, M.A. (Cantab.).*

Plant Breeding: J. C. HAIGH, B.Sc., Ph.D. (Lond.), A.R.C.S., A.I.C.T.A.

H. HOLLAND, B.Sc. (Wales).

A. G. JOHNSON, B.Sc. (Lond.), Ph.D. (Wales).

L. E. WATTS, B.Sc. (Wales), Ph.D. (Birm.).

G. J. FAULKNER.

G. J. FROST, B.Sc. (Dunelm).

R. A. T. GEORGE, N.D.H.

Miss M. H. KNIGHT, B.Sc. (Reading). (Appointed 25/9/61)

Miss E. M. SLADE, B.Sc. (Bristol). (Resigned 20/5/61)

Assistants: Mrs. S. R. C. ADAMS (née CHURCHILL).

Miss D. E. ALLEN. (Resigned 31/5/61)

Mrs. J. M. H. AUSTIN. (Resigned 31/10/60)

Miss J. COTTON. (Appointed 28/11/60)

Mrs. P. A. DILLON.

Miss G. DRAYCOTT.

Miss B. HARVEY. (Appointed 1/9/61)

Miss P. M. MILLS.

Miss P. K. NORMAN.

Miss H. M. SILVER, C.D.H. (Chelmsford).

(Appointed 1/8/61)

Chemistry:

F. HAWORTH, B.Sc., Ph.D. (Liverpool), Dip. Ag. Sci. (Cantab.).

D. J. GREENWOOD, B.Sc. (Liverpool), Ph.D. (Aberdeen).

J. M. BRAY, B.Sc. (Wales). (Appointed 1/9/61)

T. J. CLEAVER.

D. GOODMAN.

Miss P. M. LIEVESLEY, B.Sc. (Bristol). (Resigned 23/12/60)

Assistants: Miss P. E. CHANDLER.

M. J. CLAYTON. (Resigned 29/10/60)

Mrs. M. A. HASTIE (née BENNETT).

Miss D. D. JACK. (Appointed 11/9/61)

Miss M. J. JONES.

Miss D. R. MOORE.

Miss M. STEELE. (From 12/12/60 – 23/8/61)

Physiology:

J. K. A. BLEASDALE, B.Sc., Ph.D. (Manc.).

R. B. AUSTIN, B.Sc. (Birm.).

P. C. LONGDEN, B.Sc. Agric. Bot. (Nott.). (Appointed 18/9/61)

R. THOMPSON, B.Sc. (Lond.).

Assistants: Miss C. J. BRUTON.

Mrs. S. J. DEAN. (Appointed 20/2/61)

Mrs. I. H. FROST. (Resigned 31/12/60)

B. G. HUNT.

Mrs. J. I. E. MITCHELL.

*Recognised lecturer of the University of Birmingham.

Irrigation: E. J. WINTER, M.C., M.Sc. (Bristol).
 P. J. SALTER, M.Sc. Hort., Ph.D. (Nott.).
 D. H. DREW, B.Sc. (Lond.).
 P. J. M. SALE, B.Sc., Ph.D. (Reading).
 Miss F. L. C. BLACKWALL, B.Sc. Hort. (Lond.), Dip. Hort. (Studley).
 J. B. WILLIAMS, B.Sc. (Sheffield).

Assistants: Miss J. BANNAN. (Resigned 30/6/61)
 C. E. BARTLETT. (Appointed 1/9/61)
 Miss C. DOWN.
 Miss S. J. HEMMINGS.
 R. JOBSON.
 Miss G. MARTIN. (Appointed 1/2/61)
 Miss K. VINCENT. (Resigned 31/8/61)
 Miss P. A. YOULDS. (Appointed 8/8/61)

Entomology: D. W. WRIGHT, M.A. (Cantab.).*
 J. A. DUNN, M.Sc. (Dunelm), Ph.D. (Birm.).
 T. H. COAKER, B.Sc. (Lond.), A.R.C.S., D.I.C.
 G. A. WHEATLEY, B.Sc. (Dunelm).
 J. A. HARDMAN, B.Sc. Hort. (Nott.).
 Miss J. KIRKLEY, B.A. (Cantab.).
 Miss D. A. SIMPSON, B.Sc. (Aberdeen). (Appointed 1/11/60)

Assistants: K. NIENDORF.
 H. I. SMITH.
 Miss A. HALL. (Appointed 13/2/61)
 Miss C. E. JAMESON. (Appointed 1/9/61)
 Miss C. M. LOWE.
 Mrs. G. D. MAUDE. (Resigned 31/3/61)
 Mrs. J. SELWYN.
 B. J. STOCKS. (Temporarily from 6/3/61 – 31/8/61)
 Miss J. TILSLEY. (Resigned 29/10/60)

Pathology: W. G. KEYWORTH, B.Sc., Ph.D. (Lond.), A.R.C.S., D.I.C.*
 A. G. CHANNON, B.Sc. (Aberdeen), Ph.D. (Birm.).
 R. B. MAUDE, B.A. (Dublin), M.Sc. (Nott.).
 J. A. TOMLINSON, B.Sc., Ph.D. (Birm.).
 Miss J. BRITTON, B.Sc. (Lond.).
 R. G. GARRETT, B.Sc. (Lond.).
 R. A. L. HINTON, B.Sc. (Reading).
 M. J. W. WEBB, B.Sc. Hort. (Nott.), M.Sc. (Birm.).

Assistants: D. C. CUTTRISS. (Temporarily from 6/3/61 – 30/9/61)
 Mrs. G. A. DAYES. (Resigned 31/8/61)
 Miss J. M. DOW.
 Miss M. P. INSALL.
 Miss H. O'MAHONEY. (Resigned 17/1/61)
 Miss E. M. SISSON.
 Mrs. P. E. TOMPSETT. (Appointed 6/2/61)
 Miss P. A. VAIL. (Appointed 1/9/61)

Weeds: H. A. ROBERTS, B.Sc. (Manc.).
 J. M. WAY, B.Sc. Hort., M.Sc. (Lond.). (Working under A.R.C. grant)
 Miss S. M. S. HIRD, B.Sc. (Lond.), M.Sc. (Saskatchewan).
 (Resigned 30/4/61)
 Miss F. G. STOKES, B.Sc. (Birm.). (Appointed 1/9/61)
 Bernard J. WILSON, B.Sc. Agric. (Reading).

Assistants: Miss M. S. BURTON. (Appointed 21/8/61 under A.R.C. grant)
 Mrs. A. H. T. GEORGE.
 Mrs. U. W. GIBBS. (Resigned 15/3/61)
 Miss C. A. LEADBEATER, Dip. Hort. (Studley).
 (Working under A.R.C. grant. Resigned 4/2/61)
 Brian J. WILSON.

*Recognised lecturer of the University of Birmingham.

- Statistics:** J. A. NELDER, M.A. (Cantab.).*
 G. BERRY, B.A. (Cantab.). (Appointed 1/8/61)
 Miss L. A. KEMP, B.Sc. (Lond.). (Resigned 30/4/61)
 R. MEAD, B.A. (Cantab.). (Appointed 18/7/61)
- Assistants:* Miss A. DRAYCOTT.
 Miss S. M. PALMER. (Appointed 20/2/61)
 Mrs. H. E. PERKINS (née RUSSELL). (Resigned 17/6/61)
 Mrs. C. SALLIS. (Appointed 18/9/61)
- Experiments Officer:** R. J. A. EXLEY, Dip. Hort. (Nott.). (Appointed 4/4/61)
- Librarian:** D. A. WOODROFFE, B.Sc. (Nott.).
- Photographer:** R. H. MOCKFORD.
- Farm:** *Manager:* T. J. NORWOOD.
Wellesbourne—Senior Farm Assistant:
 W. G. BROWN, N.D.A., N.D.D. (Resigned 30/11/60)
Senior Glasshouse Assistant:
 J. G. J. McGHEE, S.D.H. (Resigned 4/2/61)
 R. D. COOK. (Appointed 1/5/61)
Paglesham —Foreman: D. T. McVITTIE.
- Administration:** *Secretary* - - - G. LESSON, B.Sc. Econ. (Lond.), A.C.I.S.
Accounts Assistant - - - D. A. BARTLETT.
Administrative Assistant - - - L. C. FITZGERALD.
Director's Secretary - - - Mrs. J. M. FAULKNER.
Clerical Officers - - - Miss S. CLARKE. (Resigned 28/2/61)
 Miss D. LONG.
 Miss J. L. RISHWORTH.
 (Appointed 1/5/61)
- Assistants:* Miss B. C. GUYVER. (Temporarily from 17/10/60 – 13/1/61)
 Miss P. A. HIND. (Appointed 21/8/61)
 Miss L. L. JOHNSON.
 Mrs. K. MARKOWIAK. (Appointed 12/6/61 – part time)
 Miss S. M. L. McDONAUGH.
 Miss B. M. NUTTER, M.A. (Edin.). (Resigned 7/6/61)

*Recognised lecturer of the University of Birmingham.

REPORT OF THE DIRECTOR

After a lapse of one year building development began again in 1961 when work started on the erection of two pairs of cottages for farm staff. One cottage was completed and occupied on 6th November and the remaining three cottages were completed on 23rd November 1961. One pair of cottages is sited on each side of a spur-road leading from the middle of the crescent where the other cottages are sited.

STAFF

Appointments

On 18th July and 1st August 1961 Mr. R. Mead and Mr. G. Berry were appointed as Scientific Officers in the Statistics Section.

The following six Assistant Experimental Officers were appointed during the year:—

Miss D. A. Simpson	- Entomology	1st November 1960
Mr. R. J. A. Exley	- Experiments Officer	4th April 1961
Mr. J. M. Bray	- Chemistry	1st September 1961
Miss F. G. Stokes	- Weeds	1st September 1961
Mr. P. C. Longden	- Physiology	18th September 1961
Miss M. H. Knight	- Plant Breeding	25th September 1961

Eighteen Scientific Assistants were appointed during the year as follows:—

Mr. C. E. Bartlett, Irrigation	Miss G. Martin, Irrigation
Miss M. S. Burton, Weeds	Miss S. M. Palmer, Statistics
Miss J. Cotton, Plant Breeding	Mrs. C. Sallis, Statistics
Mr. D. C. Cuttriss, Pathology	Miss H. M. Silver, Plant Breeding
Mrs. S. J. Dean, Physiology	Miss M. Steele, Chemistry
Miss A. Hall, Entomology	Mr. B. J. Stocks, Entomology
Miss B. Harvey, Plant Breeding	Mrs. P. E. Tompsett, Pathology
Miss D. D. Jack, Chemistry	Miss P. Vail, Pathology
Miss C. Jameson, Entomology	Miss P. A. Yould, Irrigation

On 1st May 1961 Mr. R. D. Cook was promoted to the post of Senior Glasshouse Assistant.

Nine University students were employed during the summer to assist in the research sections.

Miss B. C. Guyver was appointed as a Copy-Typist on 17th October 1960. On 1st May 1961 Miss J. L. Rishworth was appointed as a Clerical Officer and Mrs. K. Markowiak was appointed, in a part-time capacity, as a Shorthand-Typist as from 12th June 1961. Miss P. A. Hind was appointed as a Shorthand-Typist on 21st August 1961.

Resignations

Miss L. A. Kemp resigned on 30th April 1961.

Miss P. M. Lievesley resigned on 23rd December 1960 to take up a research assistantship at the University College, London.

Miss S. M. S. Hird left the Station on 30th April 1961 to take up a research assistantship at the National Institute of Agricultural Botany, Cambridge.

Miss E. M. Slade resigned on 20th May 1961 to take up a post with the British Food Manufacturing Industries Research Organisation, Leatherhead, Surrey.

The following 16 Scientific Assistants resigned during the year:—

Miss D. E. Allen, Mrs. J. M. H. Austin, Miss J. Bannan, Mr. M. J. Clayton, Mr. D. C. Cuttriss, Mrs. G. A. Dayes, Mrs. I. H. Frost, Mrs. U. W. Gibbs, Miss C. A. Leadbeater, Mrs. G. D. Maude, Miss H. O'Mahoney, Mrs. H. E. Perkins, Miss M. Steele, Mr. B. J. Stocks, Miss J. Tilsley, and Miss K. Vincent.

Mr. W. G. Brown resigned on 30th November 1960.

Mr. J. G. J. McGhee left the Station on 4th February 1961 to take up a post as Horticultural Adviser with the Edinburgh School of Agriculture.

Miss B. C. Guyver, Miss S. Clarke and Miss B. M. Nutter resigned on 13th January, 28th February and 7th June 1961, respectively.

Higher degree and diploma

We congratulate Mr. L. E. Watts and Mr. M. J. W. Webb on having been awarded Ph.D. and M.Sc. degrees, respectively, by the University of Birmingham. Their theses, entitled 'Studies of the breeding behaviour in cauliflowers', and 'Studies on the influence of chemical treatments of plants on their susceptibility to powdery mildews', were based on some of their work at Wellesbourne.

We also congratulate Mr. R. A. T. George on gaining the National Diploma in Horticulture.

Leave of absence

Dr. Dunn of the Entomology Section was granted leave of absence for 2-2½ years in order to accept a post as temporary Head of the Entomology Department at the West African Cocoa Research Institute, Tafo, Ghana. Dr. Dunn sailed on 20th July 1961.

Worker from overseas

Mr. O. G. de Lisser of the Ministry of Agriculture, Jamaica, who was in the United Kingdom on a year's scholarship, spent three weeks in the Statistics Section as an unpaid observer and worker from 7th to 29th August 1961.

Conferences in the U.K. and abroad

<i>Date</i>	<i>Conference</i>	<i>Attended by</i>	<i>Title of paper</i>
21st October 1960	Department of Agricultural Bio-chemistry's Conference (Aberystwyth)	Dr. Greenwood	Microbial activities in defined soil systems.
1st and 2nd November	Seed Production Conference (Cambridge)	Dr. Haigh	Trends in breeding and their possible influence on seed production in the future.
		Mr. Holland Dr. Johnson	
7th and 8th November	Fifth British Weed Control Conference (Brighton)	Mr. Roberts Mr. Way	The response of vegetable crops to pre-emergence applications of some substituted triazines (by Mr. Roberts and Mr. Wilson).
19th and 20th December	First meeting of the British Bio-physical Society (London)	Dr. Haworth Dr. Greenwood	

<i>Date</i>	<i>Conference</i>	<i>Attended by</i>	<i>Title of paper</i>
10th February 1961	Association of Applied Biologists meeting (London)	Dr. Tomlinson	Lettuce virus diseases.
28th February	Symposium on Insecticides, Fungicides and the Soil (London)	Mr. Wright	The persistence of aldrin, dieldrin and lindane in soils.
		Mr. Coaker	The effect of beetle predators on the survival of cabbage root fly.
		Mr. Wheatley	The persistence of residues of certain chlorinated hydrocarbon insecticides in England.
14th March	N.F.U. Watercress Conference (Bere Regis)	Dr. Bleasdale	Late-flowering watercress from seed.
		Dr. Tomlinson	The control of watercress crook root disease.
20th and 21st March	Society of Chemical Industry, Fungicide Conference (London)	Dr. Keyworth Dr. Channon Mr. Maude Dr. Tomlinson	
20th–29th March	Symposium on Statistical Genetics and Plant Breeding (Raleigh, North Carolina, U.S.A.)	Mr. Nelder	Quantitative genetics and growth analysis.
23rd–24th March	A.R.C. Insecticides and Pesticides Conference (N.V.R.S.)	Talks and demonstrations by staff in the Plant Pathology, Entomology and Weeds Sections.	
20th April	Electrical Research Association (Sutton Bonington)	Mr. Winter	Irrigation of vegetables in the U.K.
14th–18th	Conference on Training in Bio-mathematics (Cullohee, North Carolina, U.S.A.)	Mr. Nelder was a discussant in the session on 'Differential equations and other items of classical analysis in biology'.	
4th–8th September	EUCARPIA Working Group on Asparagus (Esbjerg, Denmark)	Dr. Haigh	—
8th–14th September	British Society for Soil Science meeting (Dublin, Eire)	Dr. Greenwood	—
9th–11th September	Royal Statistical Society Conference (Bristol)	Mr. Nelder	—
21st–22nd September	Symposium on Insect Polymorphism (London)	Mr. Coaker	—

The Agricultural Research Council (A.R.C.) kindly provided grants to enable Mr. Coaker to visit research stations in Holland from 2nd to 8th July 1961 to see work in progress on the control of certain pests of vegetable crops; and also to enable Dr. Channon to visit research stations in Holland from 4th to 9th September 1961 to see work in progress on clubroot disease of crucifers and to study pathological techniques. The A.R.C. also provided grants for Mr. Nelder to attend the symposium on statistical genetics and plant breeding from 20th to 29th March 1961 at Raleigh, North Carolina, U.S.A., and for Dr. Haigh to join the EUCARPIA Working Group on Asparagus in Esbjerg, Denmark, in September 1961.

Lectures

About 17 lectures on various aspects of the Station's research work were given by members of staff to growers and officers of the N.A.A.S., etc., in different parts of the country during the year.

Mr. Nelder gave a course of 25 lectures to post-graduate students at the University of Birmingham on 'The design and analysis of experiments', and in November 1960 Mr. Wright gave two lectures to final honours students of the Zoology Department on 'The biology, ecology and control of certain insects of economic importance'.

Visiting speakers

Each winter since we have had the facilities of the lecture room in the new building, prominent scientists have been invited to visit us and give a lecture on their special line of work. In consequence, we have had the pleasure and benefit of listening to most informative talks and of having discussions with the speakers. We are most grateful to them and we thank Dr. Greenwood and Dr. Tomlinson for making all the arrangements.

The programme has been as follows:—

12th November 1959	..	Dr. K. Smith (A.R.C. Virus Research Unit, Cambridge)
		'Recent work on electron microscopy of viruses'.
8th December		Dr. H. L. Penman (Rothamsted Experimental Station)
		'Some physical problems in plant growth'.
9th February 1960	..	Professor K. Mather (Birmingham University)
		'Biological hazards of radiation'.
8th March		Professor R. L. Wain (Wye College)
		'Chemical basis of weed control'.
8th April		Dr. L. C. Luckwill (Long Ashton Research Station)
		'Pomology at Long Ashton'.
18th October		Professor O. V. S. Heath (Reading University)
		'Experiments on onions'.
11th November		Professor J. Heslop-Harrison (Birmingham University)
		'Experimental control of plant breeding systems'.
10th March 1961	..	Dr. D. J. Finney (Aberdeen University)
		'Selection'.
27th March		Dr. P. T. Haskell (Anti-locust Research Centre, London)
		'Sound production and associated behaviour in insects'.

Broadcast

An interview with Mr. H. A. Roberts on 29th August 1961 on the subject of residual herbicides in the soil was recorded and broadcast in the programme 'Science and industry' in the overseas service of the B.B.C.

Sporting and social activities

The first social event of the winter was an informal dance on 25th November 1960 when the lecture room was transformed into a nautical scene. On 21st December an excellent Christmas lunch was enjoyed by 95 members of the staff whose thanks go to the Canteen Committee and to the kitchen staff. The Christmas-New Year Party was held in the lecture room on 6th January 1961 and 155 members of staff and their friends spent a very enjoyable evening. This was followed by a successful children's party on the afternoon of Saturday, 7th January, with 56 children and parents present. In spite of rather dull but dry weather a summer fête was held on the sports field on 15th July and there was keen competition in all the sporting events. To complete the season, a barbecue and dance was held on 14th September. For the organisation of

these social functions we thank the Sports and Social Committee, Miss Allen (until 31/5/61), Miss Britton (from 5/2/61), Mr. Cleaver, Miss Down (Secretary), Mr. Holland (Treasurer), Miss Leadbeater (until 4/2/61), Mr. McGhee (until 4/2/61), Mr. Mockford, Mr. Ray (from 5/2/61 to 7/6/61), Miss Simpson (from 1/6/61), and Dr. Watts (Chairman).

The Stamp Club continued to meet throughout the winter months. The mixed hockey team won three of its five matches, and of the seven matches played by the tennis club they won one, drew one and lost five. The table tennis club held well-supported meetings each week and won all three of its matches. The cricket team played 12 matches, winning three, losing eight, and drawing one. The Station cricket and tennis teams were defeated at Bristol when they met the Long Ashton Research Station teams on 22nd July. We are most grateful to the staff of Long Ashton for their kind hospitality and for a very enjoyable day's sport which was again one of the highlights of the season's fixtures.

RESEARCH

On 1st, 2nd and 3rd May 1961, an A.R.C. Visiting Group inspected the work in progress at the Station and considered the proposed general programme for the six-year period 1961-67. The group consisted of Professor T. A. Bennet-Clark (Chairman), Professor D. Lewis, Mr. W. C. Moore, Professor G. C. Varley, and Professor R. L. Wain. They were accompanied by Dr. E. G. Cox, Secretary to the Council, Mr. W. G. Alexander, Mr. A. Oates, Dr. E. E. Cheesman, Mr. J. Lamb, and Dr. D. Rudd Jones. The group agreed the six-year programme with the Director, and subsequently produced a report which was adopted and agreed by the A.R.C. We are grateful to the group for the time and effort they gave in considering our affairs.

Plant Breeding

Seven F_4 and F_6 butterhead type progenies of a cross between an American crisp type of lettuce possessing immunity to downy mildew and the susceptible butterhead lettuce variety Borough Wonder were selected out of 27 and tested in the field in 1961. Borough Wonder and two other control varieties were attacked by downy mildew just prior to bolting. One F_6 progeny remained free from attack and the other six F_4 's and F_6 's were not attacked until after they had bolted.

Selections of Detroit red beet were tested in 1960 and 1961 and, when sown in March, some of them produced less than 2 per cent of bolters when harvested as an early bunched crop about mid-June. They also showed improvement in root characteristics.

Experiments have shown that seed of a certain F_1 hybrid Brussels sprout can be produced by allowing natural crossing to take place between the two inbred parent lines each of which is brother-sister incompatible. They have also indicated that seed multiplication of the inbred parents and production of the hybrid seed on a commercial scale should be feasible. In small scale trials in 1960 and 1961 the F_1 hybrid (grown from seed produced in the above manner) out-yielded the control varieties, e.g., it gave about 39 per cent higher yield of marketable sprouts than the variety Irish Elegance. Further evidence was obtained indicating that internal browning of sprouts was connected with the occurrence of frost and that loose sprouts were more prone to internal browning than firm sprouts.

Breeding work with spring cabbage has been continued and lines have been obtained which gave about the same yields of either greens or hearted cabbage as the best yielding dual purpose varieties. Heart size has been reduced and, although the colour was good, an attempt is being made to breed for a darker green colour without forfeiting earliness.

Inbred lines of the winter cabbage variety January King have been produced which are free from the common defect of rosetting and the lines having the most desirable characteristics in other respects are being used in further breeding work.

By inbreeding and selection, second and third generation inbred lines of the early summer cauliflower variety Mechelse were raised which gave higher yields and curded about one week earlier than the parent variety. Evidence has been obtained that F_1 hybrids between certain early summer cauliflower varieties exhibited hybrid vigour but it did not appear that it would be worth while exploiting this commercially.

With autumn cauliflowers, first inbred generations have been compared with mass-pollinated progenies from the same selected parent plants and with the commercial parent varieties. In general, the behaviour of the inbreds conformed reasonably well with expectation based on previous studies of the breeding system of this crop.

Small scale trials in 1960 and 1961 of a number of F_1 hybrid onions from crosses between different pairs of inbred lines—one of each pair being male sterile—showed that some of the hybrids gave yields which were superior to those of control varieties.

Some of the F_2 families from crosses between self-blanching varieties of celery and certain green varieties have been found to contain self-blanching plants which were more tender than standard self-blanching varieties.

Breeding and selection for canker resistance and good root shape in parsnips, carried out jointly with the Pathology Section, have given two promising lines which are undergoing tests in several places.

Breeding work was continued with peas, outdoor tomatoes, summer lettuce (non transmission of mosaic virus through seed) and asparagus.

Nucleus stock seed of those Cambridge varieties which are on the market was again supplied to the N.I.A.B. for the production of stock seed. The stock seed will be distributed to recognised seed growers for the production of commercial seed under the scheme described in the Annual Report for 1952.

Chemistry

The three long-term field experiments begun in 1954 are still in progress. Shallow rotavating used regularly as the primary cultivation for vegetables has shown a consistently adverse effect on the yields. While shallow ploughing has given better yields than shallow rotavating, in general it has been slightly inferior to deep ploughing, and to shallow ploughing together with subsoiling. Apart from the occasional exception, the manuring treatments have continued to give the following effects—FYM to give higher yields than the fertiliser treatments, hoof and horn meal to produce about the same yield response as the equivalent quantity of Nitrochalk, split doses of Nitrochalk to be rather less effective than a single large dose, potash treatments to cause quite large yield responses, and phosphate treatments to give only small increases in yield.

The residual effect on yield in 1961 of FYM applied annually from 1954-59 (i.e., the second year's residual effect) as compared with the effect of annual applications of FYM from 1954-61, was a decrease of about 8 per cent with leeks and early summer cauliflowers but there was little or no decrease with autumn lettuce, Brussels sprouts and peas. Taking the first year's residual effect into consideration also, it appeared that, on the whole, the rate of fall off in productivity following the discontinuation of FYM applications at the end of 1959 was very slow.

In 1954, in the three long-term experiments, a single application of 20 tons per acre of FYM on land which had not received FYM for many years resulted in increases in yield of from 20 to 50 per cent with many different vegetables. When this treatment was tested again in another experiment in the same field in 1961, however, the FYM gave little or no increase in the yield of red beet, summer cabbage and onions.

An experiment, starting after a four year ley, showed that the amount of soil compaction under the ploughing depth of 12 inches was no greater when wheeled tractors were used for ploughing and all subsequent cultivations, than when crawler tractors were used. Moreover, the two treatments did not differ in their effect on the

yield of vegetable crops. This part of the experiment lasted for four years. When the depth of ploughing was reduced to 9 inches on the same plots, however, a different result was obtained after two years. It was found that the wheeled tractors had produced a slightly but significantly greater amount of compaction of the previously disturbed soil layer lying between 9 and 12 inches deep, than the crawler tractors. In the second year also the wheeled treatment gave a significantly higher yield with two of the crops, early peas and late red beet, than the crawler treatment.

For some years it has been seen that very young seedlings of carrot and red beet were bigger on plots which had received annual applications of FYM than on plots which had received annual applications of inorganic fertiliser only. The bigger seedlings were found to have a much higher potassium content and it has now been shown experimentally that there was also a good correlation between the potassium content of the seedlings and the concentration of potassium in the nutrient medium.

Studies on soil aeration were continued. It was shown previously that a very low concentration of oxygen in the water at the surfaces of soil micro-organisms had to be reached to change the decomposition of organic matter from an aerobic process into an anaerobic and denitrifying process. The amount of available plant nutrients in a soil will depend to some extent, therefore, on the proportion of the soil which has reached this very low concentration of oxygen. Methods are now being developed and tested for measuring this proportion indirectly. They involve the measurement of oxygen diffusion between and into soil crumbs, and the study of the effects of the shape and size of crumbs.

The effects of different degrees of aeration on the growth of vegetable seedlings in sand culture have also been studied. Poor aeration greatly reduced the depth of penetration of the roots of cabbage seedlings but it produced only a small reduction in the weight of leaves and of roots, and the percentage reduction was greater at a low nutritional level than at a high level.

Plant Physiology

On 1st September 1961 Dr. Bleasdale became Head of the Plant Physiology Section. We are grateful to Mr. Winter for having carried the responsibilities as Acting Head of this Section since October 1956 in addition to his normal duties as Head of the Irrigation Section.

Onions grown from seed at row spacings of $4\frac{1}{2}$, 9, $13\frac{1}{2}$ and 18 inches and having different plant densities—arranged to extend from 2 to 27 plants per sq. ft.—gave the highest yield when the rows were $4\frac{1}{2}$ inches apart with 10 plants per ft. of row. With onion sets, the yield increased as the plant density increased from 2 to 12 plants per sq. ft., and varying the row width, within reason, had no appreciable effect on yield. Allowing for the cost of sets and planting, however, the best net return was obtained from a plant density of 3.5 plants per sq. ft.

Dark-Skinned Perfection peas sown on 8th May gave the highest yield of shelled peas (at a tenderometer reading of 105) at the highest plant density used, 8.4 plants per sq. ft., but when allowance was made for seed costs it appeared that the best net return would have been given by a plant density of 10 plants per sq. ft. grown on a square pattern of arrangement of the plants. To achieve this, previous experience suggests that a sowing rate of about 26 stones per acre in rows $3\frac{1}{2}$ inches apart should be used.

Further research has been conducted jointly with the Statistics Section on an extension of a mathematical model to describe plant density/yield relationships, and on experimental designs for the study of the effects of plant density and/or pattern of plant arrangement on yield.

An experiment with carrots sown on 1st June indicated that, when harvested about mid-September, a sowing rate of 2 lb. per acre with a row spacing not wider than 12 inches was probably the best for the production of a ware crop, and that a sowing rate of 4 lb. per acre was better than 2 lb. per acre for a canning crop. When harvested near the end of October, however, the total yield was nearly doubled, and the highest yield of ware carrots was obtained from a sowing rate of 4 lb. per acre with 4-inch row

spacing, while the highest yield of canning grade carrots was produced at the same sowing rate with 16-inch row spacing. Another study with carrots showed that the more nearly square the pattern of arrangement of the plants, the higher was the total yield produced.

Growth studies on red beet were continued and, as usual, FYM produced much greater increases in yield than N, while P and K had insignificant effects. FYM promoted early leaf and root growth up to seven weeks, whereas the higher of the two levels of N had relatively little effect on early growth but sustained growth as the plants became older. Growth rate data for the past three years are being studied with the object of finding a mathematical model which will enable the treatment effects to be separated from the fluctuating year-to-year weather effects.

An experiment in 1961 confirmed previous evidence that harvesting onion seed in an immature state and drying it at too high a temperature had an adverse effect on the germination of the seed and on the viability of the seedlings. The results suggested also that seed which had received both treatments gave bulbs which were smaller than those produced by good seed of the same stock.

Sand culture experiments have shown that a low phosphorus (P) content of the culture reduced the size of watercress plants, the yield of seed they produced, and also the P content of the plants and of the seed. These low P seeds gave smaller plants than high P seeds when grown in low P culture but not when grown in high P culture. The behaviour of the next generation of seeds again depended upon the P content of the culture in which the seed bearing plants were grown.

A joint experiment at Luddington E.H.S. in 1960-61 indicated that the amount of internal browning of sprouts was increased on Brussels sprout plants that had received nitrogenous fertiliser and was very slightly decreased on those which had received potassic fertiliser.

Thin black polythene film used either to cover all inter-rows or only alternate inter-rows of a crop of outdoor tomatoes in 1961, did not affect earliness but gave increases in the yield of marketable fruit of 2.9 and 2.2 tons per acre, respectively, over the uncovered control yield of 11.6 tons per acre.

In each of three years it has been found that when translucent polythene or clear PVC was used in Dutch lights the crop of winter lettuce was less early than when glass was used. Clear cellulose acetate and fibreglass both gave as early a crop as glass did in 1959-60 but gave a later crop in 1960-61. All four materials have given similar yields of marketable lettuce.

Irrigation

In an experiment with sweet corn in 1961, even although 6.6 inches of rain fell on the crop, restoring the soil to field capacity each time a moisture deficit of one inch was reached—four irrigations each of one inch—gave an 18 per cent increase in yield. A similar yield increase was obtained, however, with four irrigations each of one quarter-of-an-inch, thus indicating that reduction of the amount of water applied does not necessarily lead to a reduction in yield response.

Irrigation experiments carried out jointly with the N.A.A.S. Experimental Horticulture Stations were continued. With early potatoes at Efford and with main-crop potatoes at Luddington, the best yield responses were obtained by beginning irrigation after the tubers had reached the size of marbles, and then applying one inch of water each time the soil moisture deficit had reached one inch. At Rosewarne where early potatoes are harvested during May-June, the crop did not respond to irrigation. The yield of summer lettuce at Luddington was much increased by sowing in soil which had been raised to field capacity by the application of one inch of water.

A study was begun on the uptake of nutrients by leaves of lettuce, variety Gotte à forcer, grown in a glasshouse. Results so far suggest the possibility of increasing yield by foliar application of nutrient in a form which is rapidly absorbed.

Using nutrient solutions at different osmotic pressures, it was found that sweet corn, under certain conditions, can absorb its requirements of water and mineral salts

effectively through a part only of its root system. Similar results were obtained previously with lettuce and radish.

A study is being made of the available water capacity of different soils ranging from a coarse sand to a heavy clay so that experimental knowledge of the irrigation needs of one soil may be translated into the needs of another.

In 1959 it was found that annual applications of FYM over a six-year period of vegetable cropping at Wellesbourne had increased the available water capacity of the soil. In the next year, i.e., after annual applications of FYM over a seven-year period, this treatment had produced little effect on the available water capacity of the top six inches of soil when measured at the time leeks were transplanted in July. By October, however, and also when the leeks were harvested in December, the effect was striking; compared with July the available water capacity had increased by about 25 per cent, and about half of the extra volume of water was readily available for the plants. A long-term experiment has now been started to compare the effects produced in this respect by annual applications of FYM and of peat. In its first year, 1961, with a crop of early summer cauliflowers, the effects of the treatments and of the control were not significantly different.

Syringing of runner bean flowers with water in 1961 again failed to increase pod set but, as in 1960, irrigation at and onwards from the green bud stage in combination with FYM increased the yield of early pods by about 50 per cent. Some evidence has been obtained which suggests that higher yields of early pods are connected with higher proportions of hybrid seeds, as opposed to selfed seeds, among the seeds sown to give the crop. Some results indicated also that in 1960 the highest proportion of hybrid seeds was produced by the pods which ripened in mid-September and had resulted from flowers that had opened in mid-July.

Entomology

Evidence has shown consistently that losses at the immature stages of the cabbage root fly accounted for a high proportion of the natural mortality of the insect. Experiments have shown that carabid beetles, and probably staphylinid beetles, were important predators of eggs and larvae. Other experiments have indicated that egg mortality occurred near the soil surface during periods of high temperature, and that fewer larvae survived in dry soil than in moist soil.

Further evidence has been obtained showing that the insecticide dieldrin is very persistent in soil and that allowance should be made for residues in the soil when making further applications of dieldrin. The insecticide diazinon, however, was found to persist in the soil for only a few months, and to give very good control of carrot fly on carrots. Like dieldrin, diazinon does not cause taint or marked loss of flavour of the carrots. The times and rates of application of diazinon for mineral and fen soils have been determined, and it was also found that it can be used more efficiently when applied in a narrow band beneath the rows of carrots than when broadcast and mixed with the soil.

The extensive use of insecticides and the finding that some of them persist and remain active in the soil for several years, has drawn attention to the need for a method of detecting, identifying and measuring the quantities of insecticidal residues in soil. A chemical method for dealing in this way with small amounts of chlorinated hydrocarbon compounds in soil has been developed and is described later in this report; it is being used in a small scale survey of arable fields which have previously received insecticide treatment, and also in studies on the behaviour of insecticides in soil.

In 1961, as in 1960, the attack of the root aphid on summer lettuce was too light for treatments of the soil with insecticides to show differences in their effects. Endrin residues in soil in 1961, from applications made in 1960, were found to be biologically active, however, causing a reduction in root aphid attack.

Following the small numbers of carrot-willow aphid found in 1960 there was a striking increase in the numbers during the spring and early summer of 1961. As in the two previous years migration from winter hosts to carrots reached its peak during

the first week of June, but the heavy attack in 1961 caused severe and widespread damage to early sown crops. An experiment showed that with early sown carrots, two sprays with the insecticide demeton-methyl gave a high degree of control of the aphid which resulted in a 79 per cent increase in marketable crop yield.

Plant Pathology

The promising results obtained in 1959-60 with two methods for the control of crook root disease of watercress were confirmed in 1960-61. One method makes use of smaller doses of a finer frit containing more zinc than was tried previously. The other consists of drip-feeding a solution of zinc sulphate into the water supplying the watercress bed.

Further evidence has been obtained that losses from parsnip canker can be reduced by sowing later (May instead of March) and by singling the plants to about 3-4 inch spacing, in rows 12 inches apart. This treatment causes the roots to be smaller (about 2½-3 inches diameter) than the usual large size. Some control of the disease was also obtained by keeping soil ridged over the roots from August onwards.

In further tests of the effect of aldrin on clubroot disease of cabbages evidence has now been obtained indicating that it is the pure HHDN which is the effective constituent of the commercial preparations.

It was found that the infection of pea seeds by the fungus causing leaf and pod spot disease could be reduced from 36 per cent to 0-2 per cent by placing the seeds for three hours, at 70°C., in carbon tetrachloride containing one per cent of either captan or thiram.

In further studies on big vein disease of lettuce, forms of *Olpidium* have been found which can infect lettuce roots without causing disease symptoms on the leaves. Symptoms of big vein have been induced on lettuce plants by grafting them with scions from infected plants.

Highly purified preparations of lettuce mosaic virus have now been made, and an antiserum has been prepared which reacts specifically with sap from diseased lettuce plants. Use of this antiserum should enable the identification of the disease to be done both quickly and accurately.

Tests have shown that certain lines of Blue Lake climbing bean were highly resistant to *Fusarium* wilt disease, and that none of the varieties of runner bean tested was resistant.

Studies were begun on crater spot disease of celery. Isolates of species of the fungi *Botrytis* and *Rhizoctonia* from diseased tissue have caused lesions.

Weed Investigations

Studies of the numbers and kinds of viable weed seeds present in the soil of plots of the Chemistry Section's three long-term experiments have been made over the six-year period 1954-59, covering two cycles of a three-year rotation of vegetables. The experiments were started on corn land when it had a population of viable weed seeds of about 230 millions per acre. With clean cultivation, the total number of weed seeds present in the soil in any one year was found to be about half of that in the previous year. The population thus tended to fall at a constant rate, but when cleaning cultivations were reduced both in number and effect during the wet summer of 1958, the resultant population was double that of 1957. Of the four primary cultivation treatments, deep ploughing, shallow ploughing with subsoiling, and shallow ploughing, had similar effects in reducing the weed seed population, but shallow rotavating had a smaller effect and after six years the population was double that following the ploughing treatments. After a weedy year, ploughing reduced the weed seed population much more than rotavating. Annual applications of FYM produced no effects on either the numbers or kinds of viable weed seeds in the soil.

Further trials of several residual herbicides used as pre-emergence treatments on spring-sown broad beans have shown that the best were simazine, chlorpropham plus diuron, and dinoseb-amine. Although good results had been obtained with amiben

in 1959 and 1960, the 1961 results showed that with the higher rainfall on a light soil it damaged broad beans, French beans and peas. On the other hand amiben did not have any markedly adverse effect on carrots, parsnips and parsley but the weed control tended to be variable. A granular formulation of amiben caused crop damage in 1961 also, when applied after transplanting brassicas and when used as a pre-emergence treatment on drilled lettuce.

Three years' trials of trietazine and propazine used as pre-emergence sprays have shown that propazine gave very good results with carrots, parsnips and parsley, and that trietazine gave very good results with spring-sown broad beans, field beans and peas, but was unsafe for use with dwarf French beans. With the latter crops prometryne showed promise, and as a post-emergence treatment gave excellent weed control with carrots, parsnips and parsley.

Further trials have confirmed that if a heavy rainfall occurs after applying chlorpropham at rates of more than 0.75 lb. per acre as a pre-emergence treatment, there is a risk of severe injury to an onion crop. Chlorpropham or chlorpropham plus diuron, however, gave excellent results with onion sets, as did chlorpropham with drilled lettuce.

As pre-emergence treatments, granular formulations of chlorpropham, amiben, dinoben and dinoseb-amine gave slightly poorer weed control than the liquid forms but did not differ from the liquid forms in their effects on crop yields.

Investigations on the rate of disappearance of chlorpropham from the soil in the field have been continued using the bioassay method reported previously. It has been found that 90 per cent of the chlorpropham applied at 1 or 2 lb. per acre disappeared in less than four weeks during hot summer weather, in more than three months during the winter, and in about 6-8 weeks during spring and autumn.

Spray drift

Studies have almost been completed on the effects of five growth-regulator herbicidal sprays applied at low doses to a range of vegetables and reports of the results are being prepared for publication.

Statistics

Advice and assistance have been given as usual to the research staff, the N.A.A.S. Experimental Horticulture Stations, N.A.A.S. officers and to other bodies. Many non-routine mathematical problems arising in the course of the research at the Station have also been dealt with by the Section.

Further investigations were made of factors which might affect the accuracy of field experiments. With red beet, it was found that the edge effect on experimental plots was greater on closely spaced plants than on widely spaced plants, and that irrespective of the plant spacing the discarding of plants from a one foot wide band round the plots would eliminate edge effects, provided the plot dimensions were larger than 6 ft. $\times$ 2 ft. With carrots, the variability in size of the roots at harvest was shown to be unconnected with variation in either the seed size, speed of germination or density (plants per sq. ft.).

Tests, with a range of different vegetables, have been made on designs for field experimentation, devised jointly by the Plant Physiology and Statistics Sections, which show promise of adding considerably to our knowledge of the effects of plant density and pattern of arrangement of plants on yield.

The Director accepted invitations to serve on the Agricultural Improvement Council's Experimental Horticulture Committee, and on the A.R.C. Technical Committee on Spray Drift. He has served again on the Advisory Committees of the N.A.A.S. Experimental Horticulture Stations, and continued to serve as Chairman of the Vegetable Working Party which co-ordinates the experimental work on vegetables

at these Stations. Service was given again by Mr. Nelder on the Protected Cropping Working Party and the Vining Pea Group of the N.A.A.S., and by Mr. Winter as Chairman of the Protected Cropping Working Party and on the Natural Resources Committee (Irrigation Study Group). We are grateful to the Experimental Horticulture Stations for their continued co-operation in carrying out field experiments with vegetables in extension of those done at Wellesbourne.

In seed maintenance and multiplication work, and in trials of varieties, full co-operation continued between the National Institute of Agricultural Botany and this Station, and the Director again served on the Vegetable Trials Advisory Committee and on the Root and Vegetable Seeds Committee of the N.I.A.B.

Mr. Wright served again on the Scientific Advisory Committee of the Crop Protection Products Approvals Scheme of the Ministry of Agriculture, Fisheries and Food, and on the Taint Committee of the Agricultural Improvement Council. Mr. Winter was appointed to the Electrical Research Association's newly-formed Committee 5J. Mr. Roberts continued to serve on the Recommendations Committee of the British Weed Control Council, and on the N.A.A.S. Horticulture Herbicides Committee.

N.V.R.S. ASSOCIATION

Chairman of the Association: David Lowe, Esq., Elvingston, Gladsmuir, East Lothian.

Treasurer: Professor T. Wallace, 'Redwings', Old Church Road, Nailsea, Somerset.

Secretary: G. Lesson, Esq., N.V.R.S.

The N.V.R.S. Association was founded in 1958 to advance vegetable research and the knowledge, science and practice of vegetable production. It also aims at enabling vegetable growers to keep up-to-date with the research being done at the Station, and at encouraging the interchange of information and ideas between the staff and growers.

In 1961 the Association increased its membership from 199 to 221. During the year, three meetings of the Association were held. On 1st March, 51 members attended a Members' Day at the Station, when talks and demonstrations were given on 'Soil physical conditions affecting plant growth'. The third annual general meeting of the Association was held at the Station on 7th June 1961; the report of the Association Committee and statement of accounts for the year 1960 were adopted, and the Chairman and the other members of the Association Committee were re-elected for the ensuing year. In the afternoon, about 60 members were conducted round some of the field experiments on weed control, and an illustrated talk was given on the effects of growth-regulator spray drift on vegetable crops. On 19th October 1961, 29 members attended a Members' Day at the Station when illustrated talks and demonstrations of work on bulb onions were given.

During the year, steps were taken by the Association Committee to implement the wishes of members as to the allocation of funds of the Association. A Members' Room at the Station was furnished with ten armchairs and three coffee tables, and authority was given to the Treasurer to purchase historical books on horticulture, particularly vegetables, with a view to building up a collection of books to rank as a national library on vegetable culture.

Scholarships

With the approval and pleasure of the Executive Committee of the Station, the Association Committee also decided that the accumulated funds of the Association were sufficient to found a post-graduate scholarship for the purpose of enabling graduate students to continue their studies and to obtain further training in research, at the Station. The scholarship will be of the value of £500 per annum, and awards will normally be made for two consecutive years with possible extension for a further year. It is proposed to advertise the scholarship with a view to the first award being made as from 1st October 1962.

Special contributions to the scholarship fund were gratefully received from J. L. Clucas Ltd. and from R. J. Hewitt (Farms) Ltd.

An offer from H. J. Heinz Company Ltd. to found a second scholarship with the same object and of the same value and conditions as for the Association scholarship was also gratefully accepted. Awards of both the 'Heinz' and the Association scholarships will be made by the Committee of the Association.

The creation of an Association scholarship fulfils the aspirations of many members who have desired that the Association should make a greater contribution to the work of the Station. It is hoped that this action will also encourage growers and others interested in horticulture to join the Association. Forms of application for membership and copies of the rules of the Association may be obtained from the Secretary.

Visitors

The number of visitors to the Station during 1960-61 was 962, including the following from overseas:—

<i>Argentine Republic:</i>	Dr. A. Marzocca, Instituto de Botanica Agricola, Buenos Aires.
<i>Australia:</i>	Mr. C. E. Cole, Superintendent of Horticulture, Victoria. Mr. T. Greaves, Division of Entomology, C.S.I.R.O., Canberra. Mr. E. R. Hoare, Irrigation Research Station, Griffith, New South Wales. Mr. D. C. Terlich, Cobargo, New South Wales.
<i>Basutoland:</i>	Mr. A. C. Macintosh, Maseru Experiment Station.
<i>Belgium:</i>	Mr. F. G. P. Hargot, Shell Chemical Company, Brussels.
<i>Bolivia:</i>	Mrs. M. L. de Fernandez, Ministry of Agriculture, La Paz.
<i>Burma:</i>	Mr. U. Aye Myint, Assistant Director of Agriculture, Moulmein.
<i>Canada:</i>	Mr. W. B. Mountain, Harrow, Ontario. Dr. L. F. Ounsworth, Canada Department of Agriculture, Harrow.
<i>Colombia:</i>	Mr. J. E. Holguin.
<i>Costa Rica:</i>	Mr. K. G. Morales, Ministry of Agriculture.
<i>Cyprus:</i>	Mr. N. Aristotelous, Ministry of Agriculture, Nicosia. Mr. M. I. Hakki, Department of Agriculture.
<i>Egypt:</i>	Mr. N. Hamissa, The Supreme Council for Combined Units, Cairo.
<i>France:</i>	Mr. M. Prevost, Shell International Chemical Co. Ltd., Paris.
<i>Germany:</i>	Dr. F. Schreiber, Brunswick.
<i>Greece:</i>	Mr. E. Aliades, Ministry of Agriculture, Athens. Mr. T. L. Petrovas, Ministry of Agriculture, Athens.
<i>Holland:</i>	Mr. J. J. Astrego, Groningen. Mr. A. J. Buist. Mr. P. Gaastra, Wageningen. Mr. M. Nieuwhof, Wageningen. Mr. W. C. Visser. Mr. J. E. V. van Zanten, Sluis & Groot's, Enkhuizen.
<i>Hong Kong:</i>	Mr. R. R. Mardi, Agricultural and Forestry Department.
<i>Iceland:</i>	Dr. B. Sigurbjornsson, University Research Institute, Reykjavik.
<i>India:</i>	Mr. S. D. Rananaware.
<i>Israel:</i>	Miss A. Gordin, Agricultural Research Station, Rehovot. Mr. Z. Mitchnick, Agricultural Research Station, Rehovot.
<i>Italy:</i>	Dr. V. Marzi, Institute of Agronomy, University of Bari. Dr. F. P. Pansiot, F.A.O., Rome.
<i>Japan:</i>	Dr. K. Yabuki, University of Osaka.
<i>Jordan:</i>	Mr. M. S. Soudi, Ministry of Agriculture, Amman.
<i>Korea:</i>	Mr. Tae Dong Lee, F.A.O. Korean Association, Seoul.
<i>Libya:</i>	Mr. M. I. Jahani, Experiment Station, Benghazi.
<i>Malaya:</i>	Mr. Tang Teng Lai, Department of Agriculture, Kuala Lumpur.
<i>Mauritius:</i>	Mr. S. Montia, Department of Agriculture, Reduit.
<i>New Zealand:</i>	Mr. W. C. Clark, Entomology Division, D.S.I.R., Nelson. Mr. R. C. Dodson, Spring Creek, Blenheim.
<i>Northern Rhodesia:</i>	Mr. C. Ng'ambi, Monze Agricultural School.
<i>Pakistan:</i>	Mr. G. M. Kandaker, Assistant Director of Agriculture.
<i>Paraguay:</i>	Mr. V. Cardozo, University of Asuncion.
<i>Persia:</i>	Mr. H. A. Sheybani, Ministry of Agriculture, Tehran.
<i>Poland:</i>	Mr. R. W. Doruchowski, Department of Vegetable Crops, Institute of Soil Science and Cultivation of Plants, Skierniewice. Mr. A. Kacala, Ministry of Agriculture.
<i>Portugal:</i>	Mr. J. R. Raimondo, Seed Testing Station, Lisbon.

<i>Sierra Leone:</i>	Mr. S. A. Gardrie, Department of Agriculture.
<i>Somalia:</i>	Mr. M. I. Samater, Ministry of Agriculture, Hargeisa.
<i>South Africa:</i>	Mr. T. F. Cuthbert, Pietermaritzburg.
<i>Southern Rhodesia:</i>	Mr. P. E. L. Thomas, Henderson Research Station, Mazoe.
<i>Spain:</i>	Mr. J. M. Pire, Madrid.
<i>Sudan:</i>	Mr. Salim Amir.
<i>Thailand:</i>	Mr. S. Vaidhyakarn, Ministry of Agriculture, Rice Department, Bangkok.
<i>Turkey:</i>	Mr. B. Günay, Ministry of Agriculture, Ankara. Mr. A. Ouvener, Institute for Plant Protection Chemicals, Ankara.
<i>Uganda:</i>	Mr. R. Passmore, Cotton Research Station, Namulonge.
<i>U.S.A.:</i>	Mr. J. E. Bussart, Velsicol Chemical Corporation, Chicago. Mr. M. A. Farrell, Pennsylvania State University. Professor E. B. Oyer, Cornell University, Ithaca, New York. Mr. L. A. Yager, New York.
<i>U.S.S.R.:</i>	Mr. D. D. Kovalenko, Simferopol. Mr. S. N. Pronine, Ministry of State Farms, Moscow. Mr. S. N. Stepanov, Michurinck. Miss I. A. Yakouchkina, Ministry of Agriculture.
<i>West Indies:</i>	Mr. V. C. R. Henry, Central Experiment Station, Trinidad.
<i>Yugoslavia:</i>	Mr. V. Jasnic, University of Belgrade.

In addition, the following 28 parties visited the Station:—

1960			
1st October	...	...	Members of the West Midland Branch of the Institution of Agricultural Engineers.
8th October	...	...	Manchester University Horticulture Students' Society.
1961			
14th March	...	...	The Warwickshire Association of Teachers of Rural Studies.
20th March	...	...	Staff and students from the University College of Wales, Penglais, Aberystwyth.
22nd–24th March	...	...	Members of the conference of research workers on Insecticides, Fungicides and Herbicides.
13th May	...	...	Members of the Oxfordshire Rural Studies Association.
17th May	...	...	The Rotary Club of Kingswood, Bristol.
24th May	...	...	The N.I.A.B. Vegetable Trials Advisory Committee.
25th May	...	...	Professor A. H. Bunting and students of Reading University.
30th May	...	...	The N.F.U. Headquarters Vegetables Committee.
5th June	...	...	Studley Village Produce Association.
10th June	...	...	Members of the Horticultural Education Association.
14th June	...	...	N.A.A.S. Agricultural Officers of the Eastern and East Midland Regions.
15th June	...	...	Dr. C. E. Harrold and students of the Botany Department, University of Birmingham.
23rd June	...	...	The Agriculture Group of the Society of Chemical Industry.
24th June	...	...	Horticultural students from the Hereford Teachers' Training College.
26th June	...	...	The Principal and students from the Waterperry Horticultural School.
27th June	...	...	Claverdon and District Village Produce Association.
29th and 30th June	...	...	Members of the N.A.A.S. Vegetable Group.
6th July	...	...	The Coventry Branch of the Geographical Association.
10th July	...	...	Staff and pupils of Stoke Park School, Coventry.
11th July	...	...	Members of the Scientific Society of Bablake School, Coventry. Pupils of the King's High School for Girls, Warwick.
13th July	...	...	Long Itchington and District Young Farmers' Club.
17th July	...	...	Lawrence Sheriff School Young Farmers' Club, Rugby.
24th July	...	...	Warwick and Leamington Young Farmers' Club. Kenilworth Young Farmers' Club.
26th and 27th July	...	...	N.A.A.S. Horticultural Advisory Officers.

Acknowledgments

Special thanks are due to members of the staff who have carried out duties in addition to their normal work. Dr. Keyworth has assisted in the editing of this Annual Report, and valuable service has been given by the following committees:—

Library Committee—Dr. Haworth, Mr. Nelder and Mr. Roberts (Chairman);

Glasshouse Committee—Dr. Haigh, Dr. Keyworth, Mr. Norwood, Mr. Winter and Mr. Wright (Chairman);

Canteen Committee—Mr. Austin (Chairman), Mr. Bartlett (co-opted), Miss Blackwall (Secretary), Mr. Goodman, Miss Kirkley, Mr. Lesson (Treasurer), and Dr. Sale.

Grateful acknowledgment is also made to other members of the staff who helped in various ways, and to all the staff and employees for the loyalty with which they carried out their work.

Thanks are due to the Executive Committee and the Sub-Committees, and especially to the Chairman of the Governing Body and the Chairmen of the Committees for the assistance they have given. We are sorry to have lost the services of Dr. R. G. Tomkins on the Governing Body and on the Staff and Research Sub-Committee, and we are grateful to him for the help he has given since 1949.

We also wish to thank all our friends outside the Station, especially growers and commercial firms, who have kindly given seeds, plants and other material and who have helped in many ways during the year.

JAMES PHILP,

16th February 1962.

FARM

By T. J. NORWOOD

Wellesbourne

1960-61, considered as a whole, was a good growing year and the cropping plan, as made earlier, was closely followed.

The general farm crops yielded good harvests. About 200 tons of silage was made and approximately 150 tons of hay was baled and stored in the Dutch barns. A field of S22 ryegrass (O.S. 100) was saved for seed and successfully harvested in July. The purchase of a combine harvester and a grain auger enabled the 88 acres of wheat and 62 acres of barley to be harvested expeditiously. Cereal harvesting began by combining barley in field O.S. 126 on 25th July and ended in a field of spring-sown wheat on 30th August. Barley yields were normal for this farm but wheat yields were better than usual. Professeur Marchal winter wheat grown on O.S. 101 and July 1 spring wheat grown on O.S. 126 each won first prize in their respective classes in the cereal crop competition organised by the Stratford-upon-Avon branch of the National Farmers' Union and together, having the highest aggregate number of points, they won the Championship Challenge Trophy. The Majestic potatoes planted in O.S. 128 grew well, remained free from blight and gave a good yield.

After a wet autumn and winter, conditions improved and vegetable planting started early in March. By the middle of that month all the early cauliflowers had been planted out and the first drillings of onions, peas and parsnips had been made. Over-wintered vegetables such as broccoli, lettuce and salad onions made rapid progress when growth resumed in the spring and, together with early spring-sown or planted vegetables, yielded very satisfactory crops. As the season advanced aphid attacks on the brassica crops were persistent and spraying with insecticides had to be done frequently. Much use had to be made of the irrigation system from May to September. Root crops, particularly onions and carrots, were better in quality and yield than in the previous year. All were harvested under conditions as near to ideal as could be expected in this country.

During the winter 81 bullocks were fed in yards. Of these, 41 were sold for beef from the yards, while the remaining 40 grazed on the pastures from April onwards and were sold for beef as they reached maturity. The herd of pedigree Large White pigs was maintained and of the 370 graded for bacon, 83 per cent were in the two premium grades. It is estimated that about 650 tons of farmyard manure was produced and all this was ploughed into the fields for vegetable production.

Paglesham

The Paglesham farm, in common with many other farms in Essex, suffered from a surfeit of rain in the autumn of 1960. As a direct result seven acres of potatoes were not harvested until February, ploughing was delayed and no winter wheat was sown. Favourable conditions in the spring, however, enabled all the leeway to be made up and spring cereals were sown in the fields which had been scheduled for winter wheat. Yields of grain, however, were not as good as those normally produced at Paglesham since the growth had suffered considerably from the waterlogging of the ground in the previous year.

There was a considerable loss of plants in some of the Brussels sprout plots over-wintered for seed production and yields were consequently less than the high yields we usually obtain there. As at Wellesbourne, aphid attacks on the brassica crops were persistent and had to be controlled by frequent spraying.

Of the 39 cattle wintered in the covered yards, four were sold for beef in the spring; the remainder were grazed on the leys and were sold as they reached maturity during the summer. The small herd of breeding sows was maintained and 216 store pigs were sold locally.

PLANT BREEDING REPORT

By J. C. HAIGH

It is hoped to enter the first products of the breeding programme described in previous Annual Reports in trials conducted by the National Institute of Agricultural Botany in the 1962 season. Potential new varieties of Brussels sprouts, cauliflower, red beet and lettuce have reached this stage.

In addition to the projects described below, progress has been made towards the production of an early maturing winter hardy wrinkled-seeded pea (suited equally to processing or early picking in the garden), and work is continuing on the breeding of an outdoor tomato variety resistant to *Didymella*, and of a higher-yielding good quality asparagus.

Lettuce (L. E. Watts and R. A. T. George)

The incidence of downy mildew (*Bremia lactucae*) at Wellesbourne was such that it was thought sufficient, up to the summer of 1960, to expose successive generations of descendants of the cross, 45634M (mildew resistant, crisp type material from the U.S.A.) x Borough Wonder (mildew susceptible) to natural infection in the field, and to select plants of good morphological type from the uninfected material. However, in 1960 no downy mildew infection occurred and in consequence lettuce seedling progenies of all the 1960 selections were tested in the glasshouse for resistance to the disease by A. G. Channon of the Plant Pathology Section. Of the 33 progenies tested in this way (16 F₄ and 12 F₆ hybrid progenies of the butterhead type and 5 S₃'s from the original 45634M), 27 proved to be resistant under glasshouse conditions.

These 27 resistant progenies were grown for observation and also in yield trials in 1961, together with the varieties Borough Wonder, Rudiger and All the Year Round as controls. The observation plots were planted in mid-April and mid-May, in order to take advantage of an early appearance of downy mildew. The two yield trials of four and three randomised blocks with 20 plants per plot, were planted one in early June and the other in early July, respectively, so that plants would be hearting at the optimum time for infection by *Bremia*, which is mid/late September at Wellesbourne.

As it happened, the *Bremia* attack occurred so late that it had not appeared by the time the lettuce had been ready for cutting for some days. It was decided, therefore, to leave one block of each trial and to cut the remainder in order to get yield data. The control varieties in the uncut blocks became severely infected with downy mildew just prior to bolting; the progenies on the other hand remained healthy at this time, but after they had bolted, 23 of them showed infection of the senescent basal leaves and the lower floral bracts, while one F₆ and three S₃'s showed no infection.

The yield and other data from the trials, for the 11 progenies selected for further work, are given in Table I, together with the assessment of infection in the uncut blocks.

Only one of the butterhead type progenies in the first trial gave a lower yield than Borough Wonder, one of its parents, and the increase in yield over Borough Wonder of all other butterhead progenies (although only four were significantly greater in the first trial) is probably attributable to the influence of the 45634M genotype. The butterhead type progenies, in general, were a few days later in hearting than Borough Wonder. Four of the progenies were completely resistant, one being an F₆ butterhead type, and others showed a high degree of resistance to downy mildew. Although some of the progenies were apparently as susceptible as All the Year Round, this was not strictly correct since no leaves and only the floral bracts remained to become

TABLE I

Yield and performance of selected Bremia-resistant lettuce progenies 1961

Progenies and control varieties	Mean Yield per plant (gm.)		Days from sowing to hearting relative to Borough Wonder		Days from hearting to bolting		% plants with no infection on 5/10/61	
	1st trial	2nd trial	0=72 days	0-66 days	1st trial	2nd trial	1st trial	2nd trial
			1st trial	2nd trial				
Butterhead types:								
45634M x B. Wonder								
F ₂ 's								
61/1	235	219	3	3	26	33	11.0	43.8
61/13	204	208	2	6	27	28	53.9	0
45634M x B. Wonder								
F ₂ 's								
61/2	270	213	-1	8	30	24	87.5	88.2
61/3	320	251	4	0	23	30	64.3	31.3
61/4	346	280	2	11	30	23	100.0	100.0
61/26	278	252	0	3	31	35	100.0	88.2
61/30	309	285	5	3	26	32	100.0	72.2
Crisp types:								
45634M								
S ₂ 's								
61/5	399	243	12	14	20	29	100.0	100.0
61/33	334	294	12	13	19	28	100.0	100.0
61/36	355	238	11	9	21	31	—	55.6
61/37	344	228	11	12	20	28	100.0	100.0
Controls :								
B. Wonder	222	205	0	0	28	26	0	0
Rudiger	242	201	3	9	24	27	0	0
All the Year Round ...	265	162	2	1	21	28	12.5	66.7
L.S.D. P=0.05 between 2 means = ± 50 excluding crisp types.			No sig. diffs.					

Yield figures in italics are significantly better than those for Borough Wonder.

Yield figures in 1st trial for F₂ hybrids 61/3 and /4, and S₂'s 61/5, /33, /36 and /37 are also significantly better than those for All the Year Round, the best yielder of the control varieties.

infected on the plants of All the Year Round at the time when most of the vegetative leaves were still present on the progenies.

In trials of six of these progenies held at N.A.A.S. Experimental Horticulture Stations, and consisting of three randomised blocks with 25 plants per plot, downy mildew was found only on vegetative plants of the two controls, Borough Wonder and Rudiger, although it was also found on plants of the progenies (with the exception of 61/5) when they had been in a bolted condition for some time. Yields of the progenies are shown in Table II and it is noteworthy that 61/3 and 61/4 gave significantly higher yields than Borough Wonder at Rosewarne and in one trial at Wellesbourne.

In an attempt to produce an improved butterhead type capable of hearting earlier and bolting later than varieties at present available, crosses were made between the varieties Borough Wonder and Rudiger. Borough Wonder is one of the most popular

TABLE II

*Mean yield per plant (gm.) of Bremia-resistant lettuce progenies at
N.A.A.S. Experimental Horticulture Stations, 1961*

Progenies and control varieties	Efford	Luddington	Rosewarne	Stockbridge House
Butterhead types:				
61/1	269	213	149	165
61/2	239	241	195	157
61/3	322	344	203	167
61/4	268	289	231	164
61/6	275	233	120	120
Crisp type:				
61/5	363	491	202	333
Borough Wonder	241	243	135	143
Rudiger	240	266	161	160
	No sig. diff. between progenies (excluding crisp type)	L.S.D. P=0.05 between 2 means = ± 66 (excluding crisp type)	L.S.D. P=0.05 between 2 means = ± 54 (excluding crisp type)	No. sig. diff. between progenies (excluding crisp type)

Yield figures in italics are significantly better than those for Borough Wonder.

lettuces in this country, while Rudiger was shown in N.V.R.S. trials (Ann. Rep. 1954, p. 16) to be one of the earliest hearting and latest bolting varieties. Similar attempts have been made by inter-crossing other pairs of varieties, such as Webb's Wonderful and Tom Thumb, but the progenies were discarded because of various morphological defects.

Thirty-five F_4 progenies were grown in three randomised blocks with 20 plants per plot, and selected plants from each of the five progenies whose yields are shown in Table III were retained for the production of a further generation.

TABLE III

Yield and performance of lettuce hybrid progenies, 1961

Progenies and control varieties	Mean yield per plant (gm.)	Days from sowing to hearting relative to Borough Wonder (0=63 days)	Days from hearting to bolting
F_4 's			
Rudiger x { 61/54*	205	— 3	26
Borough { 61/70	147	— 3	29
Wonder { 61/69	155	— 1	27
{ 61/166*	217	0	25
{ 61/177*	170	2	23
All the Year Round	192	— 1	25
Rudiger	209	6	22
Borough Wonder	160	0	28

Three of the five progenies hearted slightly earlier than Borough Wonder, and only one showed a slight extension of the period from hearting to bolting. Three progenies, indicated by asterisks, produced higher yields than Borough Wonder, though not significantly so, and they also remained marketable throughout the period from hearting to bolting, whereas the commercial controls deteriorated more quickly. Prospects for further improvement probably lie in crossing these progenies with late bolting varieties, and subsequently selecting for the non-bolting character, together with that of the ability to remain hearted without deterioration.

Red beet (H. Holland and G. J. Frost)

Further trials were carried out during 1960 and 1961 on non-bolting lines of Detroit beet for an early bunching crop which were produced by the method previously described (Ann. Rep. 1955, p. 12).

The 1960 trial compared four non-bolting lines and two commercial varieties as controls sown on 18th March in four randomised blocks with 100 plants per plot. Bolters were recorded as they appeared and on 27th June half of each plot was harvested when the plants were judged to be ready for bunching. The other half of each plot was left for seed production. Records were made of the visibility of rings, and of internal colour, texture and shape of roots, each character being graded from 1-5 with 1 as the best grade. The diameter of each root also was measured. Table IV gives the mean gradings of each character.

TABLE IV

Characters of selected red beet lines sown on 18th March 1960

Line	Mean gradings (1=best, 5=poorest)				Mean diameter (cm.)	% bolters
	Rings	Colour	Texture	Shape		
60/1	<i>1.92</i>	<i>1.00</i>	<i>1.06</i>	<i>1.00</i>	5.44	<i>0.0</i>
60/2	2.39	<i>1.10</i>	<i>1.10</i>	<i>1.00</i>	6.63	<i>0.0</i>
60/3	<i>2.19</i>	<i>1.44</i>	2.10	1.25	6.12	12.5
60/4	2.27	1.97	1.94	2.00	5.74	0.0
Control 1	2.89	1.96	2.54	1.78	4.85	82.8
Control 2	3.35	1.98	2.35	1.85	4.88	83.4
L.S.D. (P=0.05) ...	0.57	0.48	0.54	0.66	0.84	—

Figures in italics are significantly better than those of either control.

All the lines were better than the controls in reduction of bolting and in at least two of the other five characters. Line 60/1 was the best, however, being significantly superior to the controls in all characters except diameter.

In 1961, seven other non-bolting lines were tested against the same two controls in an early sowing made on 9th March. These non-bolting lines were produced by selecting first of all against bolting for two generations, the seed having been sown in January and the seedlings having been given 24-hour daylight for 21 days, and then this was followed by two more generations of selection against bolting where the seed was sown in the open early in March. Included in this trial was a monogerm line which had shown good promise for uniformity, colour and bolting resistance in 1959. The trial was arranged in five randomised blocks with 150 plants per plot and was primarily used to compare bolting performance. A second trial of the same kind of layout and with the same seven lines and one commercial variety as control was sown on 11th May and was used for comparing relative growth rates in the absence of bolting. There was insufficient seed of the monogerm line for it to be included in the second trial.

In the early sown trial, bolters were first recorded in early May in the control varieties only and by mid-June, when the roots could have been harvested as a bunched crop, a little bolting had just occurred in the lines. Final bolting figures were taken in October when the roots were harvested and selected for seed production.

In the later sown trial the diameters of the roots were measured twice each week from 14th August until 11th September when the roots were harvested and yield records were taken. The roots were also graded for texture, colour and rings on a 1-5 basis as in 1960. Table V gives a summary of the results for the two trials.

TABLE V
Characters of selected red beet lines, 1961

Line		Sown 9th March 1961		Sown 11th May 1961					
		° bolts mid-June	° bolts October	Mean root wt. (gm.)	Rings	Colour	Texture	Mean diam. 14th June (cm.)	Mean diam. 11th Sept. (cm.)
61/1	...	1.9	30.0	201.75	1.32	1.03	1.02	4.13	6.31
61/2	...	8.2	46.4	181.20	1.29	1.00	1.00	4.13	6.17
61/3	...	4.1	41.1	288.38	1.83	1.00	1.00	4.20	7.06
61/4	...	1.6	26.5	291.20	1.48	1.03	1.00	4.18	7.52
61/5	...	5.2	47.2	168.60	1.20	1.00	1.01	3.95	5.89
61/6	...	1.9	21.4	215.40	1.37	1.01	1.05	3.65	5.90
61/7	...	1.0	25.5	211.55	1.37	1.03	1.00	4.28	5.43
Control 1	...	50.8	100.0	—	—	—	—	—	—
Control 2	...	58.4	100.0	144.23	1.72	1.09	1.04	3.55	5.40
Monogerm		7.7	68.1	—	—	—	—	—	—
L.S.D. (P=0.05)	...	—	—	95.80	0.31	0.07	0.05	0.79	0.88

Figures in italics are significantly better than those of the control(s).

Lines 61/4 and 61/7 seem to be the most promising ones and it is hoped that it will be possible for them to be included in N.I.A.B. trials in 1963.

The resistant strains bolted more than those tested in previous years, but the comparison is not a strict one, since the material in this trial had been multiplied for two generations with less stringent selection against bolting. It is evident, therefore, that selection pressure must be maintained if the high degree of resistance to bolting is to be retained. The percentage of bolting in mid-June 1961, however, was so small as to be of no consequence.

Brussels sprouts (A. G. Johnson and G. J. Faulkner)

A hybrid Brussels sprout, which small scale tests have shown can be produced by natural crossing between two inbred lines in the field, is to be submitted to the N.I.A.B. for trial. The two parent inbred lines have been derived from Cambridge No. 1 and Cambridge Special. The first test of natural hybridisation between these lines gave 99 per cent of hybrid seed from the Cambridge No. 1 parent (S_2 generation) and 52 per cent of hybrid seed from the Cambridge Special parent (S_3 generation), the remaining seed being the result of sib-crossing (Ann. Rep. 1959, p. 15). The test has been repeated with material which is one generation further advanced in inbreeding, i.e., the S_3 generation of the No. 1 line, and the S_4 generation of the Special line, and has given similar results for the percentages of hybrid seed produced. The average seed yield in both tests was about $\frac{3}{8}$ oz. per plant. When the mixed seed (hybrid and sib-crossed) was drilled in the seed-bed, the more vigorous hybrid seedlings suppressed the growth of the sib seedlings and at planting time were easily identified, not only by their size but also because they differed in colour and leaf shape.

Each of the inbred lines, when isolated, produced about 2 gm. of seed per plant by sib-pollination. This represents about 600–800 seeds per plant, which should suffice for purposes of multiplication. Plants derived by sib-pollination in this way have behaved in the same manner when used for hybridisation as plants derived by enforced self-pollination.

The hybrid is early, of medium height, and produces sprouts of very good surface quality and density, with an average diameter of $1\frac{3}{8}$ inches. The colour is medium green, somewhat better than that of other early varieties but is not so dark as that of the late Bedfordshire types. Table VI shows that the hybrid (grown from naturally crossed seed) has given significantly higher yields than standard varieties with which it has been compared in trials, e.g., an average of about 39 per cent higher marketable yield than Irish Elegance. These trials had five randomised blocks with either 20 or 30 plants per plot, planted at 3 ft. square.

TABLE VI
Marketable yields of Brussels sprouts (tons per acre)

	Season 1960–61		Season 1961–62		Mean
	Wellesbourne	Paglesham	Wellesbourne	Paglesham	
Hybrid	8.07	5.49	6.50	4.94	6.25
Cambridge No. 1 ...	5.29	2.88	5.57	3.71	4.36
Irish Elegance ...	5.23	3.79	4.64	4.32	4.50
Evesham grower's strain ...	5.64	not grown	4.91	3.75	4.77
Mean	6.06	4.05	5.40	4.18	
L.S.D. (P=0.05) ...	0.91	0.92	0.45	0.62	

Investigations are also continuing with other inbred and hybrid material. A setback has been experienced, however, in the production of hybrid seed from male sterile plants. In the first field scale hybridisation test on male sterile parents, made in the spring of 1961, the seed set on many of the plants was inadequate for commercial purposes. This may have been a seasonal effect, or the result of lack of pollen virility in the particular pollen parents chosen, or it may have been a characteristic of the male sterile inbred lines themselves. These possibilities will be tested and selection made for greater female fertility if necessary.

Internal browning of Brussels sprouts (G. J. Faulkner)

Experiments were carried out to test the earlier observations (Ann. Rep. 1955, p. 15) that internal browning (I.B.) might be connected with exposure to frost, and might be more common in loose sprouts. If these factors are of importance, it is possible that intensive selection for both frost resistance and greater solidity of sprouts could produce a response in the reduction of I.B. Furthermore, since the amount of I.B. varies between and within seasons it would be helpful in selecting against it if more were known about the cause and likelihood of its occurrence.

To test the connection between I.B. and frost, Brussels sprout plants were protected by polythene covers whenever frost was forecast or whenever the ambient temperature fell below 40°F., and the covers were not removed until the air temperature had risen above 40°F. Control plots were left uncovered throughout the winter. The trial consisted of four randomised blocks, each plot containing six plants of Ashwells, a variety of the Bedfordshire type. Each plot was separated from its neighbours by a guard row.

Since the control plots in this experiment could provide only a small sample on which the possible correlation between I.B. and looseness of sprout could be tested, observations were made also on about 300 plants of the variety Rearguard, also of the Bedfordshire type, grown in the field without any protection.

In both experiments, five picks were made between October 1960 and February 1961 at approximately monthly intervals, 10 sprouts being removed from the base of each plant at each pick, cut open, and scored for I.B. and internal density. A sprout in which the internal leaves were so tightly packed that no air spaces were visible was scored as solid, whereas a sprout in which about 35–40 per cent of the internal volume consisted of air spaces was scored as very loose. Two intermediate grades were also scored. It should be noted that the sprouts in the 'very loose' grade were quite marketable by commercial standards.

No frost occurred before the first pick, and no I.B. was found at that pick in sprouts from any of the material. However, from October 1960 to February 1961, 41 air frosts occurred and the lowest recorded air temperature was 26°F. The polythene covers did not entirely prevent frost in the covered plots but they reduced it considerably. Combining the remaining four picks there was an average of 8 per cent of sprouts with I.B. in the exposed plots, while an average of 0.25 per cent of sprouts with I.B. occurred in the covered plots. The difference was highly significant ($P=0.01$). Although the presence of the covers could have had effects on the plants in addition to the protection from frost, this result suggested that the incidence of I.B. was connected with the amount of frost.

No I.B. was found in solid sprouts of either Ashwells or Rearguard. In the latter, out of 504 solid sprouts none had I.B., and of 1,892 nearly solid sprouts 0.87 per cent had I.B. or possible I.B. (however slight). In contrast, out of 3,188 moderately loose sprouts 3.3 per cent had I.B., and of 6,209 very loose sprouts 7.8 per cent had I.B. These differences were highly significant ($P=0.01$). Similar results were obtained from the unprotected plots of Ashwells, but since the sample was small, the figures are less reliable. Thus it appeared that loose sprouts, with many air spaces, were more susceptible to I.B. than firm sprouts.

To facilitate analysis, the 'moderately loose' and 'very loose' grades were combined, and the number of sprouts in them expressed as a percentage of the total sprouts in all four grades. In both varieties, the percentage of loose sprouts and the percentage of I.B. increased significantly in successive picks. There was, however, no difference in the percentage of loose sprouts between the protected (covered) and unprotected plots of Ashwells. There was also no difference between the unprotected plots of Ashwells and of Rearguard, either in percentage of loose sprouts or percentage of sprouts with I.B.

If, as appears from this work, loose sprouts are more prone to I.B. than solid sprouts, plants which produce loose sprouts are more likely to have a higher incidence of I.B. than plants which produce solid sprouts. If this were established, it could be used to aid selection against I.B. in seasons when little I.B. occurred. The results were examined, therefore, on a plant to plant basis. Considerable differences were detected between plants in the proportion of loose sprouts produced, but no significant correlation was found between this and the number of sprouts with I.B. per plant. Although 41 frosts were recorded during the period of these experiments, in seven of them the temperature was only fractionally below 32°F., in a further 18 it was not less than 30°F., and the lowest temperature of 26°F. occurred five times. The average amount of I.B. from the second pick onwards was only 8 per cent, and it is possible that with so low an incidence the sprout sample which could be obtained from each plant was too small to cover random variation in the distribution of I.B. Nevertheless, a trend towards correlation between I.B. and looseness in any one plant could be detected, and further experiments will be made in the 1961-62 season.

Spring cabbage (A. G. Johnson and G. J. Faulkner)

The breeding material grown in the season 1960–61 consisted of (a) second inbred generation (S_2) lines from selected S_1 plants from each of four commercial varieties, (b) progenies derived separately from each of the S_1 plants by mass pollination with the other selected S_1 plants from the same variety, and (c) F_2 families from intervarietal

crosses between selected non-inbred plants. Thus the material was at a similar stage of breeding to that grown in 1959–60, but was derived from different varieties.

The progenies derived by mass pollination were compared both with good varieties for the production of 'spring greens' and with good varieties for 'spring cabbage' production. The trial consisted of three randomised blocks each containing 38 plots with 40 plants per plot. Each plot was divided into two sub-plots of 20 plants each, one of which was harvested as greens and the other as cabbage.

Some of the commercial varieties included as controls were the best yielding dual purpose varieties, i.e., those which gave a high yield both as greens and as hearted cabbage. These varieties, however, all produced large hearts, whereas the present market trend is towards a smaller-hearted cabbage. Six of the mass pollinated progenies gave yields of both greens and marketable hearted cabbage which were not significantly less than those of the best yielding dual purpose varieties, and in addition had a smaller heart of about $1\frac{1}{2}$ lb. average weight. The good yield of these lines, in spite of the lower heart weight, resulted from greater uniformity which rendered more of the hearts marketable. It will probably be necessary to carry out spacing trials to determine whether a greater yield per acre can be obtained by closer planting of these small-hearted lines. The depth of green colour of the breeding lines was as good as that of the controls but still left room for improvement. Winter hardiness could not be assessed in the 1960–61 season owing to the mild winter, and bolting did not occur even in varieties known to be susceptible.

Selections were made from the S_2 lines and the F_2 progenies for further breeding work, with an emphasis on dark green colour associated with earliness. A number of F_2 progenies derived from varietal crosses showed promise in this respect.

Winter cabbage (A. G. Johnson and G. J. Faulkner)

Nine second inbred (S_2) generation lines were obtained from selected plants of an S_1 line of January King which showed no rosetted plants in the 1959–60 season. Seven of these lines, represented by 700 plants in all, had no rosetted plants; the other two lines each had about $1\frac{1}{2}$ per cent of rosetted plants. There were also differences between the nine lines in colour, heart and leaf shape, and general plant form but six of them gave over 90 per cent of top quality marketable hearts. As a result of inbreeding depression the heart weight was a little under 2 lb., as compared with $2\frac{1}{2}$ –3 lb. in the non-inbred controls. This reduction in heart weight is desirable, and hence it is not proposed at present to seek hybrid vigour by the production of F_1 hybrids. Plants have been selected from four of the best of these lines with the intention of producing bulk seed by mass pollination between sib plants of the same inbred line. It remains to be seen, however, whether a satisfactory seed yield can be obtained in this way, since the seed production of the S_1 plants was somewhat low. It is not known whether this was the result of inbreeding depression, or whether it was a manifestation of the generally poor seed set experienced in brassica material at Wellesbourne in 1960.

Cauliflower (L. E. Watts and R. A. T. George)

S_2 and S_3 lines of the early summer cauliflower variety Mechelse were grown in 1961 to test for retention of vigour following inbreeding, and to select if possible an early curdling line of good quality. In 1960, three of the four S_2 lines had given significantly higher yields than the parental control and the S_1 derived from it. The earliest S_2 with the best quality, which was the lowest yielder however, was used for selection and S_3 's were raised from it. In 1961, one of its three S_3 progenies gave a significantly higher yield of 18 per cent more than the S_2 parent, while the other two gave similar yields to the S_2 parent. The increased yield of one S_3 progeny may have been connected with a slightly later maturity date, but the general yield level and the high curd quality of all lines indicate that this inbreeding produced no adverse effect.

Although the period of harvesting was not fore-shortened the inbred progenies matured approximately a week earlier than the commercial parent.

In the Annual Report for 1959, p. 17, early summer cauliflowers were shown to be self-compatible, and as they are quite uniform in the field it was assumed that they were almost equivalent to pure lines and, therefore, might be expected to show hybrid vigour on crossing. A 5×5 diallel series of crosses was made in 1960 between the varieties Cambridge No. 7, Cambridge No. 8, Record, All the Year Round and van den Berg's No. 35. The progenies were grown in 1961 in four randomised blocks with five plants per plot and the results are shown in Table VII.

TABLE VII

Plant yield and curd size of parents and F_1 progenies from a diallel series of crosses between early summer cauliflower varieties, 1961

	Mean wt. of whole plant (gm.)		Mean curd size (inches)	
	Variety	All F_1 's with variety as one parent	Variety	All F_1 's with variety as one parent
Cambridge No. 7 ...	1081	1178	4.8	5.2
Cambridge No. 8 ...	1192	1348	5.0	5.4
Record ...	1069	1292	4.8	5.1
All the Year Round ...	1708	1570	5.4	5.3
van den Berg's No. 35 ...	1256	1103	4.9	5.1

A comparison of the plant weights of the varieties Cambridge No. 7, Cambridge No. 8, and Record with those of the F_1 plants of which they were one parent gives some evidence of hybrid vigour, but this was exhibited to a greater degree in the curd sizes for hybrids of all varieties except All the year Round. However, in view of the large measure of uniformity prevailing in summer cauliflowers, the difficulty of raising hybrid seed, and the lack of a strikingly large amount of hybrid vigour, it is doubtful whether the production of F_1 hybrids is practicable or worth while.

With autumn cauliflowers, previous studies showed that they were self-incompatible in varying degree whereas early summer cauliflowers were generally self-compatible (Ann. Rep. 1959, p. 17). S_1 progenies and mass-pollinated progenies from single selected plants of six varieties of autumn cauliflower were compared together with their commercial parent varieties in a trial consisting of three randomised blocks with 10 plants per plot. There were no significant differences in yield of whole plants between the 16 mass-pollinated progenies and their corresponding commercial parent varieties. S_1 progenies from reasonably self-compatible parent plants varied in their yield performance and some gave significantly higher yields than their commercial parent varieties. On the other hand, it appeared that S_1 progenies from rather highly self-incompatible parent plants tended on the whole to have lost vigour. Curd quality of the selfed progenies showed some improvement over that of their commercial parent varieties, but did not show any appreciable improvement over that of their corresponding mass-pollinated progenies. The S_1 progenies showed no general improvement in uniformity.

Onions (H. Holland and G. J. Frost)

A preliminary test of hybrid material was previously reported (Ann. Rep. 1959, p. 17) and further tests were carried out on new hybrids during 1960 and 1961. Hybrid seed for the 1960 trial was produced by pollinating eight inbred male-sterile progenies of a line K_1 having had male sterility bred into them, with three inbred male-fertile progenies of Cambridge No. 10. Of the 24 possible combinations, seed was obtained from 20 only, as one of the male parents flowered too late to pollinate four of the

females. The 20 hybrids were sown in a field experiment having four randomised blocks with 750 seeds per plot (equivalent to $6\frac{1}{2}$ lb. per acre). The following three control varieties were also included, Cambridge No. 10, line K_1 and a commercial variety generally recognised as being one of the best for yield and keeping qualities. Cambridge No. 10 and line K_1 were sown at three seed rates equivalent to 5, $6\frac{1}{2}$ and 8 lb. per acre, the middle rate being the same as that used for the hybrids. The field germination of the control varieties was so low, however, that none of the three seed rates gave a plant stand comparable with that of the hybrids. In the analysis of the data, therefore, the yields from the seed rate of $6\frac{1}{2}$ lb. per acre were used for comparison of actual yields, and adjusted yields were determined on a basis of 15.3 plants per foot which was the mean stand over the whole trial.

The period during which the crop was grown in 1960 was one of the wettest on record and harvesting was later than normal. However, most of the hybrids were harvested on 23rd August, whereas the three controls were not ripe until the second week in September. Records were taken of the numbers and weights of marketable bulbs in each of three size grades (Ministry Recommendations) and the numbers of unmarketable types. Two hundred bulbs were then selected from each treatment for storage tests. Table VIII gives the results obtained from the three controls and the best hybrid.

TABLE VIII

Performance of best onion hybrid and controls, 1960

	Best hybrid	Controls			L.S.D. ($P=0.05$)
		Commercial variety	Cambridge No. 10	Line K_1	
% field germination ...	<i>74.4</i>	57.2	30.8	38.4	15.5
Plants per ft. ...	<i>18.6</i>	14.3	7.7	9.6	3.9
Marketable yield { Actual	<i>27.8</i>	21.4	13.1	14.9	5.1
(tons/acre) { Adjusted	<i>25.2</i>	22.1	18.8	19.2	4.4
Mean bulb weight (gm.) ...	<i>47.3</i>	49.3	62.2	58.1	13.2
% waste at harvest ...	<i>0.8</i>	6.2	12.1	16.8	
% sound after storage until mid-February 1961 ...	<i>47.5</i>	41.5	30.0	23.0	

Figures in italics are significantly better than those of all controls.

The hybrids germinated in the field much better than the controls, although there were no significant differences between them in germination tests. Thus the stand of the hybrids was greater than that of any control, and this tended to reduce the mean bulb size and contributed towards greater uniformity. In fact, the mean bulb weight of the best hybrid was significantly less than that of its Cambridge No. 10 parent. The actual yield of this hybrid, however, was significantly higher (30 per cent) than that of the best of the controls, and even the adjusted yield was significantly higher than that of either of its parents. Only part of the actual increase in yield therefore, could be attributed to the fact that the hybrid had more plants per foot and less waste at harvest than any control. The remainder of the increase must have resulted from hybrid vigour. The hybrid also stored slightly better than the best control. The six best yielding hybrids will be tested again in trials in 1962.

The 1961 trial tested new hybrid material produced from the parents giving the seven best hybrids in the 1959 trial, against Cambridge No. 10 as control, but eight of the hybrids which had sufficient seed remaining after the 1960 trial were also included. The eight hybrids were not the best yielders in 1960. From the results of the latter trial, it appeared that $3\frac{1}{2}$ lb. of hybrid seed per acre and $6\frac{1}{2}$ lb. of control seed per acre should have given approximately equal plant stands at harvest, and hence these seed rates were used in 1961, together with a lower (5 lb.) and a higher (8 lb.) rate for the

controls. The control germinated better than it did in 1960, however, and the rate of 5 lb. per acre gave the same plant stand as that of the hybrids. Table IX shows the results for the best hybrid in each series and the control at equivalent plant densities. The mean stand for the trial of 7.7 plants per foot was used in calculating the adjusted yields.

TABLE IX
Performance of best onion hybrids (sown at 3½ lb. per acre) and control (sown at 5 lb. per acre), 1961

	Best 1961 hybrid	1960 hybrid best in 1961	Control Cambridge No. 10	L.S.D. (P=0.05)
% field germination	41.9	<i>62.5</i>	42.2	13.8
Plants per ft.	5.9	8.8	8.9	1.9
Marketable yield { Actual	<i>15.7</i>	<i>16.4</i>	10.6	4.4
(tons/acre) { Adjusted	<i>16.5</i>	<i>15.6</i>	9.8	5.1
Mean bulb weight (gm.)	<i>88.0</i>	59.7	56.2	18.5
% waste at harvest	2.5	5.3	34.1	
% sound after storage until mid-February 1962	81.0	71.0	53.0	

Figures in italics are significantly better than those of all controls.

The field germination of the control variety was equal to that of the 1961 hybrid but was significantly lower than that of the 1960 hybrid. Thus, since the two hybrids were sown at the same seed rate, the plant stand of the 1961 hybrid was significantly lower than that of the 1960 hybrid and hence its mean bulb weight was significantly greater. The plant stand of the control, however, was equal to that of the 1960 hybrid and hence the mean bulb weights of these were not significantly different. Both actual and adjusted yields of the hybrids were significantly greater than those of the control and, as far as the 1960 hybrid is concerned, its superiority in yield was mainly due to very much less waste at harvest. It is noteworthy that the 1961 hybrid also had a very low percentage waste at harvest, and this together with its heavy bulbs more than compensated for the low plant stand.

The marketable yield level of the 1961 trial was lower than that of the 1960 trial. This was the result of (a) sowing the hybrids at a lower seed rate in 1961 than in 1960 in an effort to obtain plant densities similar to the control, and (b) the much greater proportion of waste in the Cambridge No. 10 crop in 1961 than in 1960—in both years the Cambridge No. 10 plant stand and total yield were about equal. Conditions for ripening and drying the bulbs were very poor in 1961 but the hybrids again stored much better than Cambridge No. 10.

Celery (A. G. Johnson and G. J. Faulkner)

An objective method for the assessment of tenderness in celery by means of a standard commercial tenderometer is being developed. The reading obtained is affected by both the pith and the string but, since the latter is the toughest constituent of the stem, differences between readings are largely the result of differences in toughness of the string.

Progress has been made in an attempt to improve the tenderness of self-blanching celery by breeding to reduce the quantity and strength of the string. Using the method outlined previously (Ann. Rep. 1958, p. 16), each of the self-blanching varieties Cornell 19 (non-bolting strain) and Golden Marvel was crossed with each of the green varieties Monarch White, Special Market White, and Summer Pascal. F_2 progenies from these crosses have given the expected segregation ratio of three green : one self-blanching. The self-blanching plants in some F_2 's proved to be considerably more

tender than standard self-blanching varieties, in both subjective and objective tests. The green segregants were also tested for tenderness, and no evidence was found of linkage between self-blanching and toughness. Selections for further breeding have been made from among the self-blanching plants of the best F_2 lines, on the basis of both tenderness and other commercially desirable characteristics.

A number of American varieties of green celery have also been tested as potential parents for crossing with self-blanching types to improve tenderness. These varieties are normally grown on the flat, as is self-blanching celery, and many of them are exceptionally tender. A series of crosses of self-blanching x American green has now been made, and the F_1 generations will be grown in 1962.

Parsnips (H. Holland)

Since 1954, work has been in progress, in collaboration with A. G. Channon of the Plant Pathology Section, on the breeding of parsnips resistant to canker. The original resistant material was obtained from the Royal Horticultural Society's gardens, Wisley, in the form of six lines, each of which had been selfed for two generations and selected each time for freedom from canker.

During the years 1955-60 inclusive, three successive generations have been rigorously selected first for freedom from canker and secondly for good shape. In this way, the number of lines has been reduced to two, both of which have shown high resistance to canker and uniformity in size and shape. Trials are in progress at five places in the country to compare the performance of these lines with the Offenham variety.

The cool wet summer of 1960 provided ideal conditions for black canker development but in spite of this the resistant lines, grown in a trial at Wellesbourne, were only very slightly infected. The mean canker lesion size of the best line was 1.15 sq. cm. per root, whereas it was 35.92 sq. cm. in the control variety Offenham, and 49.2 per cent of the roots were attacked as against 86.0 per cent in the control.

SEED PRODUCTION

Nucleus stock seed was produced of the following varieties in 1961:—

Brussels sprouts	..	Cambridge No. 1	} at Paglesham
		Cambridge No. 3	

Plants of the following varieties were grown for the production of seed in 1962:

Brussels sprouts	..	Cambridge No. 1 (for nucleus stock seed)	} at Paglesham
		Inbred line of Cambridge Special.	
		Inbred lines of Cambridge Special and Cambridge No. 1 inter-planted for the production of hybrid seed.	
		Inbred line of Cambridge No. 1 ..	

at Wellesbourne.

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CHEMISTRY REPORT

By F. HAWORTH

FIELD EXPERIMENTS

After the wet autumn and winter of 1960–61, it was difficult to prepare a satisfactory tilth for the sowing of onions and the planting of summer cauliflowers, summer cabbage and early potatoes. The cumulative beneficial effects of annual applications of FYM on the workability of the soil were clearly seen under such difficult conditions. Despite the wet winter, the spring cabbage crop was apparently not harmed until during the first warm period in early April when the plants on many of the plots wilted. Such plants were found to have few active roots and it appeared that most of their roots had rotted during the winter. Nevertheless, the plants grew well in April (without irrigation) and good yields were obtained. During the dry summer the experimental crops were irrigated, either to get them well established or to prevent them from dying from lack of water. Irrigation was also used after the early summer crops to enable the ground to be ploughed and prepared for the succeeding autumn crops. Without such irrigation it would not have been possible to drill or plant red beet and autumn cauliflowers on the nitrogen experiment, lettuce and leeks on the cultivation experiment, and red beet, lettuce and late peas on the soil compaction experiment.

Full details of the revised treatments and crop rotations on the cultivation, nitrogen and NPK-FYM factorial experiments were given in the Annual Report for 1960, p. 19.

Cultivation experiment

The cultivation treatments in this experiment were not altered in 1960 but the manurial treatments were changed to

- b 1. N, P and K, applied after ploughing or rotavating.
- b 2. FYM before ploughing and N, P and K after ploughing or rotavating.
- b 3. Residual FYM (from applications given in 1954–59): N, P and K after ploughing or rotavating.

The three ploughing treatments, deep, shallow with subsoiling, and shallow alone did not differ in their effects on the yield of leeks, harvested December 1960, and of Brussels sprouts, harvested from October 1960 to January 1961, but all three treatments gave 10 per cent higher yields of both crops than shallow rotavating as the primary cultivation. Differences between the effects of the four cultivation treatments on the yield of early summer cauliflowers, however, were all small and not significant.

The manurial treatment FYM+NPK (b_2) produced an 8 per cent greater yield of leeks than NPK in presence of residual FYM (b_3) and about 70 per cent greater yield than NPK fertilisers alone (b_1). The response pattern of early summer cauliflowers to the manurial treatments was similar to that of leeks; the yield from FYM+NPK (b_2) was 8 per cent higher than that from NPK in presence of residual FYM (b_3), and was 40 per cent higher than that from NPK fertilisers alone. On the other hand, the three manurial treatments produced about equal yields of Brussels sprouts.

With peas and autumn lettuce, there were marked interactions between the effects of the cultivation treatments and those of the manurial treatments on the yields of both crops. In the presence of FYM+NPK (b_2) the four cultivation treatments all gave about equal yields of peas. Similar yields were obtained when the three ploughing treatments were given with NPK and residual FYM (b_3), or NPK alone (b_1), but the

shallow rotavation treatment gave yields which were 20 per cent and 40 per cent lower, respectively. The four cultivation treatments with FYM+NPK (b_2) also gave about equal yields of autumn lettuce; these yields were not different from those produced by the three ploughing treatments in presence of NPK and residual FYM (b_3), but were approximately twice those from the ploughing treatments where only NPK fertilisers (b_1) had been applied. However, while shallow rotavating with FYM+NPK (b_2) or NPK with residual FYM (b_3) gave yields of autumn lettuce only 3 per cent lower than those from the corresponding ploughing treatments, the crop failed completely on plots which had been rotavated and had received only NPK fertilisers (b_1). The fall off in yield on those plots on which FYM applications were stopped in 1960 and which have since received NPK fertilisers alone was small, but was larger on the rotavated plots than on the ploughed plots.

Nitrogen experiment

In 1961 the responses of early potatoes to the manurial treatments followed the same pattern as in previous years: FYM increased yield by about 55 per cent over the fertiliser-only treatment even though the rates of application of phosphatic and potassic fertilisers had been increased. Hoof and horn meal and Nitrochalk (whether in a single dose or four smaller doses), in equivalent quantities on a nitrogen basis, gave almost equal yields.

FYM with fertilisers, and fertilisers alone gave about equal yields of autumn cauliflowers which followed the potatoes, and the differences between the effects of the different nitrogen treatments were small and were not significant. This lack of response to FYM is in sharp contrast to the 40 per cent increase in yield of early summer cauliflowers produced by a similar FYM treatment on the cultivation experiment.

On plots where FYM had been applied to each crop for eight years, the yields of summer cabbage and of red beet were 25 per cent and 35 per cent higher, respectively, than from plots where fertiliser alone had been used, despite the increases in the fertiliser rates introduced from 1960. In contrast, a single application of FYM in 1961 to plots which had received fertiliser-only for the previous seven years, gave increases in yield of summer cabbage and of red beet of only 8 per cent and 12 per cent, respectively.

When the onion crop was drilled in mid-March, it was considered that seed-bed conditions were better on plots which had received FYM for eight years (including 1961) than on those plots which had not received FYM, but the numbers of seedlings which emerged on the two series of plots were not different. However, the seedlings on the FYM-treated plots grew more rapidly than those on the other plots, and gave a 45 per cent higher yield at harvest. A single application of 20 tons per acre of FYM in 1961 to plots which had received only fertiliser for each of the previous seven years had practically no effect on the yield of onions. As mentioned above, a similar kind of result was obtained with summer cabbage and red beet.

NPK-FYM factorial experiment

The general pattern of the yield responses of early potatoes, spring cabbage, carrots and red beet to the different fertiliser treatments in 1961 was similar to that for the years 1954–59. The divergence from this pattern in 1960 by early potatoes and red beet, particularly in response to potash fertilisers, was not maintained in 1961. The potash treatments produced a 50 per cent increase in the yield of early potatoes and about 20 per cent increases in the yields of spring cabbage, carrots and red beet. As in previous years the effects of the phosphate treatments on yield were small and non-significant, as were also the responses of carrots and early potatoes to increasing amounts of nitrogenous fertiliser. The growth of red beet was stimulated by the nitrogenous fertilisers but, because of the relatively poor stand of plants in this experiment, many of the roots grew so large that they were unmarketable. With spring cabbage, however, the nitrogen treatments produced large increases in the yield;

treatment N_2 (12 cwt. per acre Nitrochalk 15.5 per cent N) and treatment N_3 (18 cwt. per acre Nitrochalk) produced increases of 55 and 67 per cent, respectively, above the yield from treatment N_1 (6 cwt. per acre Nitrochalk).

The FYM treatment produced large increases in yield over the fertiliser-only treatments but those of 110 per cent for early potatoes and 40 per cent for carrots were larger than usual. The large increases in the yield of early potatoes was all the more noteworthy as the rates of application of fertiliser had been increased in 1960.

Rates of application of FYM

In 1961, measurements were made of the effects of FYM at rates of 0, 10, 20, 30, 40 and 50 tons per acre on the yields of summer cabbage and late red beet on land which had not received FYM for many years and was adjacent to the cultivation experiment in Soakwaters. All plots received fertiliser applications which supplied 300 lb. N, 36 lb. P_2O_5 and 192 lb. K_2O each per acre, before the cabbages were planted and 100 lb. N, 36 lb. P_2O_5 , and 192 lb. K_2O before the beet seed was drilled.

With the cabbage only the highest rate of application of FYM produced an increase in yield over that given by fertilisers alone and the difference was small. As already mentioned, a single application of 20 tons per acre of FYM in 1961 in the nitrogen experiment also produced little or no effect on the yield of summer cabbage, red beet and onions. These poor responses to a single application of FYM in 1961, therefore, appear not to be fortuitous.

On the other hand, they are very different from results obtained previously. Thus, on the same soil, a single application of 20 tons per acre of FYM in 1954 produced increases in yield of from 20 to 50 per cent with a wide range of vegetable crops. Although the rate of application of the fertilisers, with which the FYM was compared, was higher in the present experiment than in the 1954 experiments, it was not higher, except for nitrogen, than the rate used in a runner bean experiment (Ann. Rep. 1957, p. 30). In this runner bean experiment one application of 30 tons per acre of FYM produced an increase in yield of more than 100 per cent. In 1953 also, in an experiment carried out by the Entomology Section on land in a moderately good state of fertility, a single application of 30 tons of FYM per acre increased the yield of summer cabbage by 14.0 per cent as compared with a fertiliser-only treatment similar to, but lower in nitrogen than that used in the nitrogen, and rates of application experiments in 1961. The effect of a single application of FYM on yield will be tested again in 1962.

The yield of red beet increased progressively with increasing rates of application of FYM up to a rate of 40 tons per acre; the yield at this rate was 30 per cent more than the yield produced by fertilisers alone. In the nitrogen experiment red beet responded only slightly better than summer cabbage to a single dose of FYM (12 versus 8 per cent) but since the red beet in the present experiment was grown on the FYM residues after the cabbage crop had been removed, it is surprising that the differences in the yield responses of the two crops should have been as great as they were.

Soil compaction experiment

An experiment was started in 1956 after a four year ley, to compare the effect of the use of wheeled tractors and crawler tractors for ploughing and all subsequent cultivations, on the apparent specific gravity (A.S.G.) of the soil at the bottom of the furrow. Such compaction could lead to drainage impedance and could also affect crop growth. The two experimental treatments were:—

- (a) ploughing and all cultivations using crawler tractors;
- (b) ploughing and all cultivations using wheeled tractors.

The depth of ploughing in 1956–59 was 12 inches and in 1960–61 it was 9–10 inches. FYM at 40 tons per acre was applied to all plots in each autumn (including 1955) and generous applications of fertilisers were given before each crop in the three-year

rotation of summer cauliflowers, late peas; spring lettuce, autumn cauliflowers (red beet in 1960-61); early peas and autumn lettuce. There were four replications of the two treatments and there were three phases so that each crop in the rotation was grown in each year.

The treatments did not produce significantly different yields of crops in the four years 1956-59. In the autumn of 1959 the A.S.G. of the soil immediately below the ploughing depth of 12 inches was measured, but no differences were found as a result of the different treatments over the four years.

At the autumn ploughing in 1959 and in subsequent ploughings, the depth was reduced to 9-10 inches to find whether the disturbed soil in the layer extending from 9 to 12 inches deep would, in time, show differential effects of the ploughing treatments.

The treatments did not produce different yields of crops in 1960 but, in 1961, treatment (a) (crawler tractor) gave a 20 per cent lower yield of early peas and a 7 per cent lower yield of red beet than treatment (b) (wheeled tractors) and both differences were significant. The A.S.G. of the soil immediately below the reduced ploughing depth was measured in November 1961 and the mean values for soil samples from the crawler treatment (a) and the wheeled treatment (b) were 1.53 and 1.64, respectively (s.e. of the difference ± 0.019); although the difference was relatively small, it was highly significant. The experiment is being continued.

UPTAKE OF NUTRIENTS BY VEGETABLE SEEDLINGS

(F. Haworth and T. J. Cleaver)

It was reported previously (Ann. Rep. 1959, p. 21) that the potassium content of carrot and red beet seedlings from plots which had received applications of FYM for six years was much higher than that of seedlings from plots to which only inorganic fertilisers had been applied during that period.

To assess the possible effects of this extra potassium on the rate of growth of the seedlings, experiments have been done in which seedlings of lettuce, carrots, red beet, cabbage, leeks and onions were grown in composts and in sand culture at different potassium levels.

The results showed that the amount of potassium in the seedlings increased progressively as the concentration of potassium in the nutrient medium increased. There was also a good correlation between the rate of growth of the seedlings, as measured by the rate of increase of dry matter, and their potassium content. While growth experiments of this kind cannot establish a causal connection between potassium content and rate of growth, it seems reasonable to infer such a connection. It is possible, therefore, that the markedly more rapid growth of seedlings on the FYM-treated plots, as compared with that of seedlings on the fertiliser-treated plots, could have been a response to the greater amounts of potassium which they contained. The reasons for the greatly increased uptake of potassium by seedlings on the FYM-treated plots, and the effects of organic compounds of known composition on the uptake of potassium by seedlings are being studied.

SOIL AERATION (D. J. Greenwood and D. Goodman)

Oxygen diffusion through soil crumbs

The oxygen concentration in respiring soil crumbs is greater at their surfaces than at their centres. Previous work (Ann. Rep. 1960, p. 22) showed that in soil, respiration and nitrification were not inhibited, and anaerobic decomposition of organic matter and denitrification were not induced, until the oxygen concentration in the water at the surfaces of the soil micro-organisms was reduced to less than 1/200th of that in air-saturated water. The proportion of the total volume of the crumb in which aerobic respiration is occurring thus determines the balance within the soil of the aerobic and anaerobic processes, and therefore the availability of plant nutrients. As this

proportion is partly governed by the distances of the micro-organisms from the crumb surfaces, it is related not only to the sizes of the crumbs but also to their shapes. An attempt was made, therefore, to assess a 'shape' factor by cutting random sections of the crumbs and determining the distribution of lengths of random transects. Columns of moist soil crumbs were set in blocks of wax so that plane surfaces suitable for examination by reflected light could be cut in any direction through the columns. Using an apparatus constructed with the co-operation of our photographer, R. H. Mockford, enlarged images of these surfaces were projected on to a ground glass screen, and measurements of transects were made directly on this screen.

The method of assessing crumb shape was tested by determining the distribution of transect lengths for objects of known shape and size, and was found to be adequate. With spheres, the distributions were compared directly with those calculated theoretically by J. A. Nelder. With other shapes the distributions were used to calculate surface area/volume ratios which were then compared with the ratios determined by direct measurement. The results of measurements on sieved aggregates from one soil indicated that shape was independent of size. If this result applies to many soils, and work on other materials suggests that it might (4), then transect length distributions could also be used to determine crumb sizes. It should be possible, therefore, after determining the effect of the shape of the crumb on its oxygen distribution, to use measurements of transect lengths in assessments of the proportion of the total volume of soil which was under anaerobic conditions.

In the first experiments on the effect of 'shape' of soil crumbs on their respiration rates, crumbs were cut to the required dimensions and their respiration rates were measured under different oxygen partial pressures. Lowering of the oxygen partial pressure surrounding moulded spheres of soil caused decreases in their respiration rates which approximately fitted the following amended formulation of a previous theory (2):— $6D(C - C_0) = MR^2(3 - 3(1 - K/M)^{\frac{1}{2}} - 2K/M)$ where the symbols are as previously described (2).

These experiments, however, were complicated by the instability of the soil shapes and by variations in their diffusion constants, and hence attempts have been made to develop a method based on the use of shapes prepared from yeast, agar and nutrient solution.

The above work has been carried out in conjunction with J. A. Nelder, to whom acknowledgment is made.

Oxygen diffusion through the gas-filled space in columns of soil crumbs containing inter-crumb water

Experiments have been continued on the effects of varying amounts of inter-crumb water on the respiration of columns of soil crumbs. The procedure has been improved with the result that agreement between the respiration rates obtained experimentally and those derived theoretically, from measurements of gaseous diffusion, is better than that obtained in our earlier work (Ann. Rep. 1960, p. 23).

Denitrification

Work on denitrification has been continued and some of our earlier findings (Ann. Rep. 1960, p. 23) have been confirmed. Because of the dependence of denitrification on the physical condition of soil, it was important to study the process under defined conditions such as can be maintained in electrolytic rocking percolators (3). It was found that solutions containing glucose, ammonia and nitrate percolated through crumbs of Water Meadows' soil, only lost nitrate when the oxygen supply was poor. When loss of nitrate did occur, the loss of nitrate+nitrite-nitrogen equalled the loss of total-nitrogen. Irrespective of the nitrogen loss the utilisation of atmospheric-oxygen+nitrate-oxygen was approximately constant. It was thus concluded that under these experimental conditions nitrate was not converted into cellular

material or ammonia, and thus denitrification in percolators could be followed by analysing samples of percolate for nitrate and nitrite. An equation deduced from Fick's law of diffusion, and requiring measurements of the crumbs' respiration rate, their size, and the oxygen partial pressure surrounding them, gave predicted values for denitrification which were in rough agreement with those found experimentally.

Soil aeration and the growth of seedlings

(D. J. Greenwood, T. J. Cleaver and D. Goodman)

Work has been started to find to what extent differences in aeration can influence the growth of vegetable seedlings in sand culture. An experiment typical of those done so far, consisted of a 4×4 latin square lay-out with two aeration treatments combined factorially with two nutrient levels. Five Primo cabbage seedlings (six days old) were transplanted on 31st August 1961 to vertical-sided pots (radius 3.5 cm., length 11 cm.). The pots for the good aeration treatment contained a mixture of sand and stones with a water table maintained 7.5 cm. from the surface of the mixture, and the pots for the poor aeration treatment contained sand with a water table maintained 3 cm. from the surface of the sand. Since the lowest water content anywhere in the pots was 12 per cent by volume and all the pores were large it was unlikely that growth was affected by shortage of water.

The high nutrient solution was a modification of that used by Hewitt (5). The concentration of nutrients as m-equiv. per litre were:—

NO_3^- 12; PO_4^{3-} 4; SO_4^{2-} 1.5 (neglecting that due to micro-nutrient contribution); Ca^{++} 8; Mg^{++} 3; K^+ 4; Na^+ 4 approx. (sodium hydroxide was used to adjust the final pH of the nutrient solution to 6.5); Fe^{+++} 0.6; Mn^{++} 0.02; Cu^{++} 0.002; Zn^{++} 0.002; B 0.033 (m-mole); Mo 0.0002 (m-mole). The iron in the nutrient solutions was added as the iron-EDTA complex and the low nutrient solution was prepared by diluting the high nutrient solution with four volumes of water.

After four weeks in a heated glasshouse the plants had their dry weights, chemical compositions and the distribution of their roots in the pots determined. Some of the results are given in the table.

Growth and composition of cabbage seedlings, 1961

Treatment		Dry weight of tops (mg.)	Dry weight of roots (mg.)	Depth of sand containing 90% of roots (cm.)	%K in dry weight of tops	%Mg in dry weight of tops
Aeration	Nutrient					
Good	Low	380	55	3.9	2.8	0.63
Good	High	730	71	3.1	3.6	0.53
Poor	Low	310	38	1.4	1.7	0.55
Poor	High	650	60	1.4	3.5	0.43
s.e. of difference between means (degrees of freedom)		33 (6)	2.6 (3)	0.11 (3)	0.10 (6)	0.016 (6)

Treatment with the high nutrient solution increased the dry weights of roots and tops, and the phosphorus and potassium contents of the tops, but did not increase their magnesium or calcium contents. The poor aeration treatment caused a great reduction in the depth to which the roots penetrated the sand but brought about only a small decrease in the dry weights of roots and tops. The decrease, when expressed as a percentage of total dry weight, was greater with the low than with the high nutrient solution. The results of chemical analyses of the tops indicated that poor aeration

accentuated the effects of a deficiency of nutrients. For example, with the high nutrient solution, poor aeration did not affect the potassium content of the tops but reduced it with the low nutrient solution. At both nutrient levels, poor aeration affected the contents of magnesium in the tops but not those of calcium or phosphorus.

The diffusion constant for oxygen, calculated for 20°C. at the surface of the sand, was $6 \times 10^{-6} \text{ cm.}^2 \text{ sec.}^{-1}$, and at the surface of the sand and stones it was $6 \times 10^{-3} \text{ cm.}^2 \text{ sec.}^{-1}$. Since the roots penetrated to more than 1.4 cm. these results indicated either that the oxygen requirements of the roots of cabbage seedlings were very low or that the seedlings, like beans (1), could transport oxygen from the leaf through the stem to the root tip.

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PLANT PHYSIOLOGY REPORT

By J. K. A. BLEASDALE

COMPETITION STUDIES (J. K. A. Bleasdale and R. Thompson)

The effects of plant density and/or pattern of plant arrangement on yield were studied in experiments on onions and peas in 1961.

A systematic design, based on a log. log. grid, was used for an experiment on the spacing of onion sets of the variety Rijnsburger. Within each main plot, plant densities ranged from 2 to 12 plants per sq. ft. and the pattern of plant arrangement ranged from square (1:1, the distance between the rows being equal to the distance between the plants within the rows) to a rectangularity of 6:1 (the distance between the rows being six times greater than the distance between the plants within the rows). With the rectangular plant arrangements both east-west and north-south row orientations were included in any one main plot. Each of the four main plots was divided into 30 sub-plots at harvest.

Neither the rectangularity of plant distribution nor the orientation of the rows had any significant effect on yield. On the other hand, as the plant density increased from 2 to 12 plants per sq. ft., total yield increased from 18 to 32 tons per acre and did not have an optimum within this range. The mean bulb size correspondingly decreased from 213 gm. to 62 gm. Although progressive increases in yield were obtained with progressively closer spacing within and/or between rows, the cost of sets and of planting were found to limit progressively the net return per acre. When allowance was made for these factors the data indicates that 3.5 plants per sq. ft., yielding about 23 tons per acre, gave the maximum net return. Under field conditions the viability of onion sets is not likely to exceed 80 per cent. Making allowance for this, a suitable spacing to give 3.5 plants per sq. ft. would be 12-inch rows with $2\frac{3}{4}$ inches between the plants within the row.

Onions of the variety Bedfordshire Champion were grown from seed in an experiment of conventional design involving four row spacings ($4\frac{1}{2}$, 9, $13\frac{1}{2}$ and 18 inches) and plant densities ranging from 2 to 27 plants per sq. ft. Assuming a 25 per cent field emergence this would mean a range of sowing rates from 2.6 to 36 lb. per acre. The data obtained agreed with a mathematical model which describes the relationship between density, pattern of plant arrangement and yield. The model predicted that all row spacings would give their maximum yield at the same density, namely, 21 plants per sq. ft., and that the relative yields at this density for $4\frac{1}{2}$, 9, $13\frac{1}{2}$ and 18-inch rows, as compared with a square arrangement, would be 83, 68, 61 and 58 per cent, respectively. The highest total yield obtained in the experiment was 27 tons per acre (18 tons of bulbs having a diameter greater than $1\frac{1}{2}$ inches, and 9 tons of pickling grade bulbs) from 27 plants per sq. ft., i.e., about 10 plants per ft. run of row, in rows $4\frac{1}{2}$ inches apart.

The data from an experiment on the spacing of peas (variety Dark-Skinned Perfection sown on 8th May) fitted the same mathematical model as was used for the onion data, but here the pattern of plant arrangement was not a variable because all densities were at a nearly square arrangement. There were six plant densities ranging from 0.7 to 8.4 plants per sq. ft. in a randomised block layout having four replicates. Each plot was split to give three dates of harvest. The yield of shelled peas at a tenderometer reading of 105 (the maturity commonly used for frozen peas) was calculated for each density. The highest yield obtained (78 cwt. of shelled peas per acre) was with 8.4 plants per sq. ft. The mathematical model indicated that this was some 95 per cent of the yield obtainable at the predicted optimum density of 13.4 plants

per sq. ft. If the seed was costed at 170/- per cwt. and the gross return for shelled peas was 55/- per cwt., the plant density giving the maximum net return was calculated to be about 10 plants per sq. ft. provided the plant arrangement was nearly square. On the basis of the plant establishment in this experiment, this is equivalent to a sowing rate of about 22 stones per acre, although on the basis of the average establishment over a number of years 26 stones per acre would be required. An inter-row spacing of $3\frac{1}{2}$ inches would have to be used to obtain a near square plant arrangement.

An extension of the mathematical model used to describe density/yield relationships has been developed to describe interspecific competition. Although most of the initial work on this model was done using the published data of other workers, additional data was required to test the validity of the model. Accordingly, a glasshouse experiment on competition between buckwheat and cabbage at the seedling stage was carried out. The results fitted the model and a paper dealing with this experiment and the mathematical models used in these competition studies is being prepared jointly with J. A. Nelder for publication.

J. A. Nelder of the Statistics Section has been responsible for much of the mathematical aspect of the above work and the development and analysis of systematic designs. His co-operation and participation is most gratefully acknowledged.

SPACING OF CARROTS (J. K. A. Bleasdale and R. Thompson)

Investigations into the effects of plant density and arrangement on the yield and size of carrot roots have been continued. In an experiment sown on 1st June 1961 in two randomised blocks, the four varieties Cluseed New Stump Rooted, Blatchford's Stump Rooted Intermediate, Elsom's Early Nantes and Elsom's Amsterdam Forcing were grown in rows 4, 8, 12 and 16 inches apart with plant densities of 8.5 and 18.0 per sq. ft. (equivalent to 2 lb. and 4 lb. of seed per acre of Cluseed New Stump Rooted, assuming a 50 per cent field emergence). There were two harvests, 11th September and 27th October; all possible combinations of these factors were used in a multifactorial design.

All the varieties responded similarly to the treatments and therefore only the mean effects over varieties are summarised here. At the earlier harvest the total yield of roots was not significantly affected by row spacing. The mean total yield from 2 lb. of seed per acre was 18 tons per acre, and from 4 lb. of seed per acre was 22 tons. However, 2 lb. of seed per acre in 4, 8 and 12-inch rows and 4 lb. of seed in 4-inch rows all gave about 15 tons per acre of ware roots. Sowing rates of 2 lb. per acre in 16-inch rows and 4 lb. per acre in 8, 12 and 16-inch rows all gave ware yields which were considerably lower than this. Thus, apart from a slightly greater uniformity of the roots in the 4-inch rows, there appeared to have been little advantage in using rows closer than 12 inches or sowing rates in excess of 2 lb. per acre for the production of an early crop of ware roots. At all row spacings and at the first and second harvests the 4 lb. sowing rate gave about 65 per cent and 125 per cent greater yield of canning size roots, respectively, than the 2 lb. sowing rate. The proportion of the total yield which was of canning size was similar at all row spacings at the first harvest, whereas at the later harvest the proportion tended to be greater from 16-inch rows than from 4-inch rows.

By 27th October the crop weights had nearly doubled and row spacings and seed rate both had marked effects. The results are given in the table. At all row spacings 4 lb. of seed per acre gave higher total yields of roots than 2 lb. Whereas this increase in total yield with 4 lb. of seed was associated with an increase in ware yield in the 4-inch rows, 4 lb. of seed gave a lower ware yield from 8, 12 and 16-inch rows than 2 lb.

The 4-inch rows gave a significantly greater ware yield than any other row spacing indicating that a higher sowing rate than 4 lb. per acre would be needed, at this row spacing, if small canning roots were required.

The mean effect of sowing rate and row spacing on the yield of four varieties of carrots (tons/acre) harvested October 1961

	Sowing rate	4" rows	8" rows	12" rows	16" rows	Mean
Total yield	2 lb./acre ...	36.35	35.08	35.28	33.02	34.93 (± 0.72)
	4 lb./acre ...	42.49	40.69 (± 1.44)*	36.37	36.04	38.89
	mean ...	39.42	37.88 (± 1.02)	35.82	34.53	
Ware yield (above 1" diam.)	2 lb./acre ...	34.49	33.08	33.34	30.20	32.78 (± 0.76)
	4 lb./acre ...	37.52	32.56 (± 1.52)	28.68	26.88	31.41
	mean ...	36.00	32.82 (± 1.08)	31.01	28.54	

*Standard error of the difference between two means with 23 degrees of freedom.

In another experiment using carrots, variety Cluseed New Stump Rooted, continuous variations in row width and seed rate were used to give three types of plot layout:—

- plants in a fixed arrangement (rectangularity 9.5:1) but with densities ranging from 1 to 50 plants per sq. ft.;
- plants at constant density (10 per sq. ft.) but with variable arrangements (rectangularities of 1.5:1 to 70:1);
- as for (b) but a plant density of 39 per sq. ft.

There were two harvests, 5th September and 24th October, and each plot was replicated twice.

Decreasing the rectangularity from 70:1 to 1.5:1 ((b) and (c) above) increased the total yield at the first harvest by 80 per cent and 94 per cent when the plant densities were 10 and 39 per sq. ft., respectively. The corresponding figures for the second harvest were 67 and 38 per cent.

The effect of increasing plant density, at a constant rectangularity of 9.5:1 ((a) above), was to increase total yield. The total yields obtained from plant densities of 1, 10, 30 and 50 plants per sq. ft. were, respectively, 5, 16, 24 and 30 tons per acre at the first harvest, and 12, 33, 45 and 53 tons per acre at the second harvest. The root sizes associated with the latter yield indicated that 93 per cent were marketable and 38 per cent were of a size suitable for canning whole.

It was thought that defoliation of a carrot crop prior to harvesting might facilitate harvesting particularly by mechanical means, and that it might also be used to arrest the growth of a crop when the roots had reached a required size, but before it was convenient to harvest. Accordingly, an experiment was carried out in which the effect of cutting off the tops was compared with killing them with a spray of Diquat ($1\frac{1}{2}$ lb. active ingredient or $\frac{3}{4}$ lb. of ion per acre). One month after treatment the yield of roots from untopped control plots had nearly doubled, whereas the yield from the defoliated plots had not significantly increased. The Diquat treatment, however, produced an off-flavour of the carrot roots and caused some damage and rotting of the crowns.

GROWTH STUDIES (R. B. Austin)

Studies on the growth of the red beet crop on the Chemistry Section's long-term NPK-FYM experiment were continued using the same plots and method as were used in 1960 (Ann. Rep. 1960, p. 30). The applications of FYM and of nitrogen significantly

increased the yield of roots at harvest in November from 11.9 tons on the control plots (low nitrogen, no-FYM) to 20.0 tons on the low nitrogen, +FYM plots, and to 15.2 tons per acre on the high nitrogen, no-FYM plots. There was no significant interaction between the effects of the FYM and of the nitrogen applications, and the effects of the phosphate and potash applications on yield were not significant. The first samples of plants were taken two weeks after sowing when seedling emergence was almost complete. At this stage there were already significant differences in cotyledon and seedling weight between plants from the control plots and those from the high nitrogen and from the +FYM plots. Until the plants were seven weeks old leaf growth continued exponentially and the relative leaf growth rates were 8 per cent greater on the +FYM than on the no-FYM plots, whereas there was no difference between the relative growth rates on the low and the high nitrogen plots. Thereafter, the relative growth rates of the leaves and of the roots declined. The decline was more rapid on the low nitrogen than on the high nitrogen plots so that the relative difference in plant size between the nitrogen treatments increased with age. On the other hand, the difference between the relative growth rates on the no- and +FYM plots became less with age and hence the relative difference in size between the no- and +FYM treatments decreased with age. Thus, with this red beet crop, FYM tended to promote early leaf and root growth while high nitrogen, which had relatively little effect on the early growth, tended to sustain growth as the plants aged.

Leaf and root growth rate data for 1959, 1960 and 1961 are being studied in greater detail and an attempt is being made to find a model based on the logistic equation, which will enable treatment and year-to-year differences to be interpreted in terms of the constants in this model.

In preliminary studies, large and significant differences in the alcohol-soluble sugar content of red beet leaves from the NPK-FYM experiment were found to be related to the treatments. Analyses of samples collected on a sunny August afternoon showed that leaf sugar contents were lower on plots which had received either applications of FYM or high nitrogen than on no-FYM, low nitrogen plots. There were also diurnal fluctuations, and day-to-day differences in leaf sugar contents which appeared to be associated with the weather differences. The results suggested that in good growing weather, assimilation may have been limited in the leaves from the no-FYM, low nitrogen plots by the rate of translocation of sugars or by the rate of their incorporation into the structure and storage reserves of the plant.

SEED INVESTIGATIONS (R. B. Austin)

Environmental effects on onion seed. A trial, similar to that reported previously (Ann. Rep. 1960, p. 32), was carried out in 1961. Uniform bulbs of the onion variety Cambridge No. 10 were selected from a crop grown at Wellesbourne in 1959 and were seeded at Wellesbourne in 1960. The seed heads were harvested on three occasions (30th August, 9th September and 19th September) and half of each lot was dried at 25°C. and the other half at 35°C. The performance of each lot of seed was assessed by sowing them in a field experiment in 1961 at the rates of 12, 24 and 36 seeds per ft. of row, corresponding to the rates of 4, 8 and 12 lb. seed per acre.

There were significant differences in the yields of bulbs at harvest which were mainly, but not entirely, related to differences in plant stand at this time. These stands depended on the initial viability of the seed (as measured by laboratory germination tests) and on the mortality of the seedlings in the field. The initial viability of the immature seed dried at 35°C. was somewhat less than that of the other lots of seed which did not differ from one another in this respect. Seedling mortality, however, was considerably greater when the heads were dried at 35°C. than at 25°C., and also progressively increased as the heads were harvested in a less mature state. The combined effects of these factors was such that the stand, at harvest, on the plots sown with the best seed was nearly twice that on the plots sown with the worst seed.

When calculated allowances were made for the effects of these differences in stand on yields, it was shown that the yields from five of the lots of seed did not differ from

one another. The yield from the most immature seed dried at 35°C., however, was significantly less than that from the other lots. Thus the immature seed dried at 35°C. was so severely affected that only one-third of the initially viable seeds ultimately produced mature bulbs and, in addition, the size of these bulbs was significantly less, at a similar stand, than that of the bulbs from the best seed.

Effects of parent plant nutrition on seed performance. In glasshouse experiments, watercress plants (*Nasturtium officinale* R. Br.) were grown and seeded in sand cultures, and were watered with Hewitt's (2) nutrient solution modified to contain either 0.2, 1.0 or 4.0 mg. of phosphorus per litre. These solutions are referred to as P1, P2 and P3, respectively. To avoid differential iron effects this element was supplied as a chelate with ethylene diamine tetra acetic acid (EDTA). Judged by plant weight and phosphorus content after flowering, and by seed yield, plants in P1 cultures were very deficient in phosphorus, those in P2 cultures moderately deficient and those in P3 cultures not deficient. Seeds from the cultures differed mainly in their total phosphorus content, which were 0.43, 0.69 and 0.92 per cent total phosphorus in the dry weight, respectively. When properly ripened, over 90 per cent of each kind of seed was viable. Seed from the P1, P2 and P3 cultures (called 'P1 seed', etc.) was then sown and grown in each of the three cultures, and the plants were harvested before flowering. When grown in P1 cultures, plants from P3 seed were significantly larger than those from P2 seed, which in turn were larger than those from P1 seed. Such differences were not found, however, when the P1, P2 and P3 seed was sown in P2 or P3 cultures. Seed was then obtained from each of the nine cultures, i.e., all combinations of P1, P2 and P3 seed sown on P1, P2 and P3 media. Seed from plants grown on a P3 medium from P1 seed was indistinguishable in its subsequent performance from seed obtained from plants grown on a P3 medium from P3 seed. Similarly, when seed was obtained from plants grown on a P1 medium from P3 seed it behaved as P1 seed. These results indicated that the difference in performance of the watercress seeds were mainly due to variations in the phosphorus content of the seeds, and that these variations affected seedling growth only when the seed was sown on a medium deficient in phosphorus. It appeared that there were no inherited nutritional effects such as were found with flax by Durrant (1). It was found, however, that plants from the original seed, grown in the P1 medium, were much more variable in size (as a percentage of their mean) than those grown in P2 or P3 media. This effect is being studied in further experiments.

Similar experiments are in progress with peas using media deficient in nitrogen, phosphorus and potassium, and with red beet using media deficient in nitrogen.

INTERNAL BROWNING OF BRUSSELS SPROUTS

(J. K. A. Bleasdale and R. Thompson)

Plants raised from a common stock of seed of a commercial variety of Brussels sprouts were grown according to normal practice at Wellesbourne and at Efford, Luddington and Stockbridge House Experimental Horticulture Stations. No sprouts were picked but each week throughout the winter a sample of nine plants were harvested at random at each centre and all the sprouts on them were examined for internal browning (I.B.).

The amount of I.B. was greatest in the plants grown at Stockbridge House E.H.S. but it never exceeded 11 per cent by number. The data indicated that I.B. increased as the season advanced and was found more often in the larger sprouts than in the medium or small sprouts. The rate at which the amount of I.B. increased with time was different for each centre but a common rate of increase appeared to describe the situation adequately if, instead of time, accumulated day degrees below 32°F. (grass min.) was used. This evidence supports the data previously presented (Ann. Rep. 1960, p. 32), indicating that frost may be one of the factors causing I.B.

The Director of Luddington E.H.S. made available plots having 11 different and established soil fertility levels. There were sufficient plots to allow for four replicates of a randomised block design to be planted with Brussels sprouts in the spring of 1960.

A single destructive harvest was made at the end of January 1961 and the results obtained indicated that nitrogen increased the amount of I.B. significantly ($P < 0.05$) and potash tended to decrease I.B. ($P < 0.1$).

It is normal practice in some areas to 'stop' Brussels sprout plants by removing the main apex in the early autumn. The effect of this on the incidence of I.B. was studied in an experiment carried out at Wellesbourne. Different plots of plants were 'stopped' each week for eight weeks from the first week in September. Neither 'stopping' nor the date of 'stopping' were found to have any effect on the amount of I.B. recorded.

PROTECTED CROPPING

Plastic films as soil mulches (R. B. Austin)

An experiment to test the effects of varying the proportion of the soil surface covered with 0.0015 inch thick black polythene film on the yield of tomatoes from the outdoor variety Harbinger, was planted on 7th June 1961. The plants were raised under glass and planted 18 inches apart in rows 42 inches apart. The experimental layout consisted of six randomised blocks each containing three plots and the treatments were (a) all inter-rows covered with black polythene (86 per cent cover), (b) alternate inter-rows covered with black polythene (43 per cent cover) and (c) control with no cover. The first ripe fruits were harvested on 28th August and picking continued until 10th October. The treatments produced no differences in earliness or degree of ripening of the fruit but they brought about significant differences in the total yields of ripe tomatoes which were (a) 15.7, (b) 15.2 and (c) 13.4 tons per acre. The yields of marketable tomatoes (all tomatoes weighing at least one ounce) were (a) 14.5, (b) 13.8 and (c) 11.6 tons per acre. The yields of green tomatoes harvested on 12th October were (a) 6.9, (b) 6.3 and (c) 5.7 tons per acre. The mean wholesale price of the tomatoes was 5.8 pence per pound, and, after deducting only the cost of the black polythene, the additional return (compared with the control plots) from the 43 per cent covered plots was £71 per acre, and was £59 per acre from the 86 per cent covered plots. Measurements indicated that the amount of available water was significantly greater in the soil covered with black polythene than in the uncovered soil, and examination of the root systems after harvest showed that under the black polythene but not under the uncovered soil, roots had developed abundantly in the upper three inches of the soil profile. This increase in the available soil water near the surface of the covered plots, and the consequent ability of the roots to exploit a zone of soil which was warmer and presumably of higher nutrient status than lower parts of the profile, was probably a major cause of the differences between the yields of tomatoes.

Glazing materials (J. K. A. Bleasdale and R. Thompson)

As in previous years (Ann. Rep. 1960, p. 33) lettuce were over-wintered in frames glazed with various plastics or glass. Each plot was a small frame taking two standard Dutch lights 'glazed' with either glass, fibre glass, wire reinforced cellulose acetate ('Claritex') clear PVC, and a double layer and a single layer of translucent polythene. There were five replicates in a randomised block layout.

The results obtained were similar to those obtained in 1959-60 in that the 'glazing' materials used had little or no differential effect on either the number or total weight of lettuce cut for market. The date on which half the total number of lettuce had been cut, however, was significantly earlier with glass (13th April) than with any of the other materials. Lettuce grown under cellulose acetate and fibre glass, which in 1959-60 were as early as those grown under glass, were five and four days later, respectively. Those under PVC and single polythene were five days later than those under glass.

In both years the lettuce grown under double polythene were the latest but, whereas in 1959-60 they were 11 days later than those under glass, in 1960-61 the difference was only six days. The experiment will be repeated in 1961-62.

Acknowledgments

Thanks are due to the Directors and staffs of Efford, Luddington and Stockbridge House Experimental Horticulture Stations for their co-operation in carrying out experiments on the internal browning of Brussels sprouts. We gratefully acknowledge the help of our colleague, J. A. Nelder, who has assisted us with the mathematical aspects of our experiments.

Thanks are due also to the Chemistry Section for the analysis of plant material, and to British Celanese Ltd., and Commercial Plastics Ltd., for the supply of materials used in the experiments on glazing and mulching.

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IRRIGATION REPORT

By E. J. WINTER

In addition to the work described below, Dr. Sale has continued his investigation of the effects of the drop size and temperature of irrigation water, while Mr. Williams has carried out further work on the effects of pollutants, especially detergents, in irrigation water. He has developed a laboratory technique using duckweed (*Lemna minor*) for detecting the presence of phytotoxic substances in water samples.

IRRIGATION OF PEAS (P. J. Salter)

Previous experiments (3) showed that on a sandy loam soil, substantial increases in the yield of peas were obtained by irrigating the crop when the pods were beginning to swell, but that irrigation between sowing and flowering time did not increase the yield. An experiment was carried out in 1961 with the object of ascertaining the manner in which irrigation at different stages of growth influenced the yield of shelled peas, i.e., whether pod number, weight or number of peas per pod, or mean weight and size per pea were affected by different watering treatments.

Ten irrigation treatments were applied using a split-plot design with four randomised blocks. The sub-plots were used for the comparison irrigation versus no irrigation at the pod-swelling stage of growth, while the main plots were used for irrigation treatments applied at other stages of growth. The quantity of water applied at each irrigation was equal to the current soil moisture deficit, except that 0.5 inch of water was applied when the pods were beginning to swell. Seed of the variety Dark-Skinned Perfection was sown on 11th May 1961 in soil at field capacity, and the plots were protected from rain throughout the experiment by movable glass shelters (Ann. Rep. 1954, p. 48).

Although the detailed statistical analysis of the data has yet to be completed, the results appeared to confirm previous findings that the yield of shelled peas was increased by watering when the pods were beginning to swell, but not by watering between sowing and flowering time. The results also indicated that irrigation when the first flowers were opening, a treatment which has not hitherto been used, may also have increased the yield of peas.

IRRIGATION OF SWEET CORN (D. H. Drew)

If, when irrigating, a smaller amount of water is applied than the current soil moisture deficit, the soil will not be restored to field capacity to the full rooting depth of the crop; thus different parts of the root system will be subject to different moisture stresses. The effects of such a treatment on yield of field crops of vegetables is being studied.

A replicated, unsheltered field experiment was carried out using sweet corn, variety North Star. Seed was sown on 8th June 1961 in soil with a moisture content near to field capacity and during growth three treatments were applied including a control (not irrigated). All plots including the controls received 6.6 inches of rain during the experiment.

Treatment (a), restoring the soil to field capacity whenever a moisture deficit of one inch was reached, i.e., four irrigations each of one inch, led to a significant increase of 18 per cent in yield of marketable ears above that of the un-irrigated control plots. Each time this one-inch irrigation was applied in (a), the plots under treatment (b) were given only a quarter-of-an-inch of water, which would be expected to restore only a part of the root zone to field capacity; here the yield did not differ significantly from

that produced as a result of treatment (a), i.e., four waterings of a quarter-of-an-inch each gave as beneficial an effect on yield as four waterings of one inch each.

Although there was a total rainfall of 6.6 inches during the experimental period, at no one time was there sufficient rain to bring the plots receiving treatment (b) to field capacity, or to cause appreciable drainage from the plots being irrigated to field capacity (a). The results of this experiment suggest that good yield responses may be obtained even where economy in the use of water is made by applying less water than would restore the whole rooting depth of the crop to field capacity.

IRRIGATION OF A ROTATION OF VEGETABLE CROPS

(E. J. Winter and F. Lucy C. Blackwall)

Field experiments on the irrigation of a number of different crops were continued in 1961 in collaboration with the staffs at Luddington, Efford and Rosewarne Experimental Horticulture Stations of the N.A.A.S. The plots were not protected from rainfall.

At Efford, all five different watering treatments applied to early potatoes increased the yield in terms of weight of ware tubers. The highest yield resulted from irrigation only after the young tubers had reached marble size; after this stage, about one inch of water applied whenever the soil moisture deficit had reached one inch (total irrigation 3.46 inches) increased ware yield by 83 per cent compared with unwatered control plots. When this watering treatment was combined with a top-dressing of 5 cwt. per acre of Nitrochalk, the ware yield was 115 per cent more than that from unwatered plots which had received no top dressing. Watering before the marble size as well as afterwards (total irrigation 4.07 inches) increased ware yield by only 63 per cent compared with un-irrigated controls, but increased the haulm weight by 53 per cent. Three other watering treatments (total irrigation 1.55, 1.20 and 1.03 inches) increased ware yield by 16, 20 and 21 per cent, respectively; with the first of these, the water was applied before the marble stage, whereas with the other two it was applied at the marble stage, and afterwards.

For the fifth year in succession, irrigation of early potatoes at Rosewarne did not increase yield significantly at the earliest harvest, even although the weather had been such that one-inch deficit treatments required the application of a total of three to four inches of water. Determination of the soil moisture characteristic (see footnote on page 46) revealed that the top two feet of the soil could hold 3.0 inches of water and this observation, considered together with rainfall records, showed that in spite of the occurrence of the appreciable deficits mentioned above, the plants were at no time subjected to serious moisture stress. These findings are not necessarily applicable to other soils in Cornwall, nor to potatoes and other crops at Rosewarne harvested later than the first harvest of early potatoes. Thus, when early potatoes at Rosewarne were not harvested until mid-June, three weeks later than usual for this crop, irrigation at one-inch deficit resulted in a significant increase of 12 per cent in yield as compared with the unwatered controls.

The yield of maincrop potatoes at Luddington was significantly increased by 35 per cent, compared with that of unwatered controls, when irrigated from the marble size onwards (total irrigation 3.90 inches). Restoring the soil to field capacity whenever the deficit reached one inch throughout the life of the crop (total irrigation 10.17 inches) increased yield by 14 per cent but this difference was not significant.

At Luddington the application of 1.26 inches of water to peas after flowering gave approximately the same increase in yield over controls as watering both before and after flowering (total irrigation 2.26 inches). In 1961, however, neither of these yield increases was significant. In this experiment all the plots including controls received 0.30 inches of water before sowing.

The comparison between watering summer cauliflowers at one inch soil moisture deficit as estimated by the Penman method, and at the same deficit according to readings of the irrigation indicator was repeated at Luddington. The marketable yield from

the 'Penman' plots (total irrigation 3.5 inches) was significantly greater (17 per cent) than that from the 'indicator' plots (total irrigation 4.5 inches). In two previous years there had been no difference (Ann. Rep. 1959, p. 32, and 1960, p. 36).

At Luddington summer lettuce was sown in soil which had been raised to field capacity by watering during seed-bed preparation (total irrigation one inch). This treatment significantly increased the weight of the marketable crop by 30 per cent and the number of marketable heads by 28 per cent compared with sowing in un-irrigated soil. Watering again when the roots had reached 9 inches depth gave no further increase in yield. The yield of spring cabbage and salad onions at Luddington, and of winter cauliflower at Rosewarne, was not increased by any of the irrigation treatments applied.

In a previous experiment at Rosewarne, the stem length of anemones had been found to be increased by irrigation (Ann. Rep. 1960, p. 37). Raising the soil moisture content to field capacity at planting time in June 1960 (total irrigation 3.45 inches) increased the number of marketable blooms by 29 per cent, and the number of high-quality, long-stemmed blooms by 86 per cent compared with unwatered controls. Additional watering, to restore the soil to field capacity whenever 0.5 inch deficit had arisen (total irrigation 5.03 inches), increased the number of marketable blooms and of long-stemmed blooms by 39 and 106 per cent, respectively. The watered plots gave a higher total yield of blooms, and more blooms with stems over 20 cm. long in November and December 1960, than the non-irrigated plots. However, the lush growth of the irrigated plants made them especially susceptible to the wet and windy weather during the early months of the year, so that their yield of blooms in February and March 1961 was less than that from the unwatered controls.

APPLICATION OF NUTRIENTS DISSOLVED IN IRRIGATION WATER

(P. J. M. Sale)

Field experiments in 1961 and 1960 (Ann. Rep. 1960, p. 37) with lettuce showed that the application of fertiliser dissolved in the irrigation water produced the same increase in yield as the application of the same amount of fertiliser in the dry form followed by irrigation. It should be noted, however, that both experiments were carried out in wet seasons. The 1961 crop was badly affected by *Botrytis*. The plots which had received dry fertiliser had significantly more diseased plants, and consequently more unmarketable plants than the plots given fertiliser dissolved in water. It is possible that damage to the lower leaves caused by contact with dry granules of fertiliser had allowed the fungus to enter.

Three experiments, designed to determine the extent to which lettuce plants (variety Gotte à forcer) may absorb nutrients through their leaves, were carried out in the glasshouse during the winter 1960–61. In one, a complete NPK nutrient solution was applied as a foliar spray to supplement a root supply which was inadequate in all these nutrients. In the second and third experiments the plants received foliar sprays of N only, in the form of urea; this was supplemented in the second experiment by supplying the roots with a solution judged to be adequate in all nutrients, and in the third experiment by an adequate supply of all nutrients except N.

In all these experiments the foliar spray solutions were more concentrated than those normally used for field application of nutrients dissolved in irrigation water. The results of the first experiment showed that, although the lettuce plants did take up some nutrients through their leaves, the quantities absorbed were insufficient to compensate for an inadequate supply in the rooting medium. On the other hand, when a solution of 50 milli-equivalents per litre of urea was sprayed on to lettuce leaves, there was a significant increase in fresh and dry weights of tops compared with unsprayed controls, even when the supply of nutrients in the rooting medium was judged to be plentiful. It now seems desirable to investigate whether the use of similar comparatively concentrated solutions of rapidly-absorbed nutrients may be beneficial under field conditions.

STUDIES ON ROOT SYSTEMS (D. H. Drew)

Glasshouse experiments on the absorption of water and mineral salts by different parts of root systems were continued, using methods previously described (Ann. Rep. 1960, p. 38). In an experiment with sweet corn, grown in gravel, the root system was divided into an inner zone and an outer annular zone, and at intervals of one to three days, depending on the weather, nutrient solution was added either to both zones or to one of them; in the latter case, water was added to the other. At each application, sufficient nutrient solution or water was used to ensure through drainage and thus to restore the nutrient concentration in the medium to the desired level. The concentrations of nutrient solution were such that their osmotic pressures covered the same range as was used in experiments in 1960 with lettuce and radish, namely, from one to four atmospheres. The results showed that there were no significant differences between the fresh weights or dry weights of tops harvested from plants given any of these treatments.

It is commonly held that sweet corn has a high nutrient requirement and since the treatments were applied during bright weather from 5th July to 8th August and the glasshouse was unshaded, any limitation of nutrient supply was expected to exert a marked effect. The fact that no significant differences were produced suggested that in the previous experiments with radish and lettuce the concentrations of nutrient solution may have been too high. Future experiments on the efficiency with which root systems absorb mineral salts, therefore, should include treatments having lower concentrations of nutrient solutions.

STUDIES ON AVAILABLE WATER IN SOILS (P. J. Salter and J. B. Williams)

The effect of farmyard manure

It has been shown previously at Wellesbourne that farmyard manure applied annually over a six-year period resulted in a significant increase in the available water capacity of a sandy loam soil (5). These investigations were continued in 1960 and determinations of the available water capacity and the moisture characteristic* of the top six inches of soil were made on three occasions during the growth of a crop of leeks, namely, in July immediately after planting, in October, and in December when the crop was harvested. On each occasion these determinations were made on soil which had received annual applications of FYM since 1953 and on corresponding soil which had received no FYM. On all plots, rotavation was used for the primary cultivations.

Available water capacity was measured by the use of techniques previously described (4) while the moisture characteristic was determined using suction plates and pressure membrane apparatus. The available water capacity of the top six inches of soil in July, October and December was 0.82, 1.15 and 1.32 inches, respectively, on the FYM-treated plots, and 0.77, 0.93 and 1.05 inches on the untreated plots. These figures showed that there was little difference in the available water capacity between the treated and untreated soil at planting time in July. After the soil had become consolidated, however, as a result of normal cultural operations, the available water capacity of the FYM-treated soil in October and December was approximately 25 per cent greater than that of the untreated soil. This increase was equivalent to about 4,500 gallons of water per acre. A comparison of the moisture characteristic of the two soils in October and December, both indicated that about half of this increase in volume of available water was held in the soil at a very low tension (below 0.33 atmosphere) and, therefore, would be readily available for plants. The determinations are being repeated during the growth of the 1961 leek crop.

*The moisture characteristic of a soil is defined by Childs (2) as the relationship between the moisture content of soil and the pressure deficiency, or suction, with which that moisture is held.

Comparison of the effects of farmyard manure and peat

A long-term experiment was begun in 1961 to compare the cumulative effects of regular applications of farmyard manure or peat, before each crop, on the available water capacity and the moisture characteristic of a sandy loam soil. By the application of peat to the soil it was hoped to simulate the effects of farmyard manure on soil physical properties, without adding appreciable quantities of nutrients, etc., and thus to distinguish the nutrient effect of FYM from its effect on soil physical properties.

The treatments were started in March 1961 before the first crop was planted and after the available water capacity had been determined for each of the six plots. There were two randomised blocks each containing three plots (plot size 7 × 6 yd.) and the treatments were:—

- A. FYM applied at the rate of 20 tons per acre per crop.
- B. Peat applied at an equivalent rate of organic matter per acre per crop.
- C. Control—no peat or FYM.

On all plots rotavation was used for the primary cultivation in order to incorporate the FYM and peat as uniformly as possible into the soil. Suitable dressings of base fertilisers were applied before planting the crop in an attempt to make nutrients non-limiting for growth.

The first crop was early summer cauliflower transplanted in March and harvested in June. The mean weight per trimmed marketable head, the mean size and number of marketable curds and the total weight of trimmed marketable heads were highest for treatment A, lowest for C and intermediate for B, although the differences were not significant. The available water capacity of the top 12 inches of soil when the crop was harvested was highest with treatment B, lowest with C and intermediate with A, but again the differences were not significant.

The effect of soil texture

An examination has been made of the available water capacity of the top two feet of 12 cultivated soils. The soils chosen ranged from a coarse sand to a heavy clay. Samples were taken in the early spring, before crops were sown, and again after the crops were harvested. The highest available water capacity in the spring was found on a deep silty loam, with 3.25 inches per ft. depth of soil, and the lowest on a coarse sand with 0.77 inches per ft. A sandy loam soil held 1.53 inches, while a clay held 1.87 inches per ft. of soil. Data on the available water capacities of the soils after the crops were harvested are not yet complete.

The determination of the available water capacity and moisture characteristic of a further range of soils is being undertaken with the object of providing information which will be useful for the application of the results of irrigation experiments carried out on one soil to soils of different textures.

STUDIES ON THE LOSS OF WATER FROM PLANT/SOIL SYSTEMS

(P. J. M. Sale)

If the amount of water lost by the transpiration of growing plants could be reduced without affecting growth, a saving in the irrigation requirements of a crop might be effected. It is well known that cetyl alcohol, a waxy solid, applied to the surface of reservoirs can reduce the evaporation loss by up to 30 per cent. Accordingly, experiments were carried out in an attempt to confirm a report (1) that plants could take up this substance through their roots thus causing a reduction in water loss by transpiration.

In a glasshouse, seeds of sweet corn, variety J.I. Hybrid, and runner bean, variety Streamline, were sown singly on 25th February 1961 in waxed cartons containing either J.I.P. 1 compost or vermiculite plus nutrient. One per cent by weight of commercial cetyl alcohol was mixed with the rooting medium in half of the cartons. There were 10 replications of each treatment arranged in randomised blocks. When the

seedlings had emerged the cartons were completely closed round the base of the stems so that all water loss would take place by transpiration only. Transpiration was measured by frequent weighing, and a known weight of water was added as required to prevent the plants suffering from water shortage. The plants were harvested six weeks after germination.

On 6th March seedlings of lettuce, variety Borough Wonder, were pricked out into waxed cartons containing vermiculite plus nutrients with or without the addition of one per cent cetyl alcohol as before; J.I.P. compost treatments were not included. There were again 10 replicates of each treatment and the water loss by transpiration was determined for six weeks in the glasshouse, the plants then being harvested.

In these experiments the growth of runner beans, sweet corn and lettuce was reduced when cetyl alcohol was present, especially in the vermiculite series of cartons where the plants showed a marked nutrient deficiency, apparently of phosphorus; and since growth was much less, the total water loss per plant was also much less. When the water loss was related to each unit of fresh weight gained, or to each unit of leaf area gained, however, the loss from cetyl alcohol-treated plants was either the same as that from untreated plants or was slightly increased; the slight increase was significant for sweet corn growing in vermiculite ($P=0.01$) and, for water loss per unit of fresh weight gained only, for lettuce growing in vermiculite ($P=0.01$).

A similar experiment was carried out in the glasshouse with sweet corn, variety J.I. Hybrid, sown in J.I.P. 1 compost on 19th May, but here the cetyl alcohol was sprayed on the foliage of the plants with the object of eliminating any possibility of the alcohol interfering with nutrient absorption through the roots. In one treatment the foliage of the plants was thoroughly wetted with a solution obtained by shaking excess cetyl alcohol with water for 24 hours; although cetyl alcohol has a very low solubility in water, its ability to form a film on a water surface suggests that such a solution may also contain some of the alcohol in a very fine suspension. In a second treatment the plants were sprayed with an 'atomised' solution of 5 gm. of cetyl alcohol in 50 ml. of ether. The ether evaporated almost completely before reaching the plants, leaving a fine deposit of cetyl alcohol on the leaves. In neither of these treatments was it possible to measure how much cetyl alcohol was actually present on the leaf surface. In a third treatment the plants were sprayed with an emulsion of 5ml. of oleyl alcohol, a related compound, in 50 ml. of water, while the control plants were sprayed with water only. The treatments were applied five times at approximately weekly intervals.

The oleyl alcohol caused considerable leaf damage which resulted in the plants growing more slowly than those given the other treatments and hence their total water loss was less. The plants given either of the cetyl alcohol sprays did not differ significantly from the control plants in leaf area or in the fresh or dry weight of either tops or roots. Furthermore, the cetyl alcohol caused no significant difference in total water loss or in water loss per unit of leaf area when compared with control treatments. The water loss per unit of fresh weight gained was significantly higher ($P=0.01$) from the ether-cetyl alcohol treatment than from either the water-cetyl alcohol treatment or the control.

A further experiment has shown no effect of cetyl alcohol on the rate of evaporation of water from a moist soil surface, either when the cetyl alcohol was mixed with the soil or when applied to the surface.

Thus, under the conditions of these experiments, cetyl alcohol did not reduce transpiration without reducing growth, either when mixed with the rooting medium or when used as a foliar spray; this result is in general agreement with a recent report on comparable work in America (7).

FACTORS AFFECTING THE SET OF RUNNER BEAN PODS

(F. Lucy C. Blackwall)

In 1961 with an early sown (10th April) 'pinched' crop of the variety Kelvedon Marvel, grown on land which had received FYM at 20 tons per acre, irrigation applied

from the green flower bud stage onwards significantly increased the early crop of pods (July—early August) by 40 per cent compared with that from similarly manured but un-irrigated plots. In this experiment irrigation was applied according to the same criteria as in 1960, but in 1961 the amounts were modified to take account of the percentage crop cover of the soil. This confirmed results obtained on a caned crop of the variety Streamline, in 1960 (Ann. Rep. 1960, p. 40). Syringing the flower trusses of the varieties Kelvedon Marvel and Princes twice each day when there was no rain (July—early August) slightly reduced the percentage of flowers which set pods, thus confirming results of three previous years. In 1961 the syringing was also associated with a slight depression in early yields of both varieties.

Seeds which ripened at different times were collected separately from a crop of the variety Streamline in 1960. Plants from these seeds were grown in 1961 and it was found that the highest yield of early pods, i.e., marketed by early August, was given by plants from seed which had ripened in mid-September and had been derived from flowers which had opened in mid-July. The lowest yield was given by plants from seed which had ripened in early September and an intermediate yield was produced by plants from ripe seed collected in early October.

White-flowered plants in the 1960 crop were used for assessing the amount of cross-pollination by red-flowered plants which occurred at different times during the season. On these white-flowered plants, flowers which opened by early July, before bumble-bee activity had reached its peak, produced only 25 per cent of hybrid seeds; flowers which opened during mid-July when insect cross-pollinating activity was maximal, produced over 50 per cent of hybrid seeds; and flowers which opened towards the end of July and early August, when the hive- and bumble-bees were collecting nectar through holes bored in the corolla-tube instead of entering (and pollinating) the flowers in the normal manner, produced only 30 per cent of hybrid seed. There is thus some evidence that the size of the early runner bean crop in 1961 may have been related to the proportion of hybrid seeds in the population from which the plants were grown. A similar condition has been reported as affecting total yields in field beans (6). Further evidence on the subject is necessary, however, before it can be ascertained whether it may be possible to improve the early yield of runner beans by sowing only those seeds which include a high proportion of hybrids.

Acknowledgments

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ENTOMOLOGY REPORT

By D. W. WRIGHT

THE NATURAL CONTROL OF THE CABBAGE ROOT FLY

(T. H. Coaker and Dorothy A. Simpson)

In the study of the natural mortality of the cabbage root fly, consistent evidence has been obtained of a high level of loss amongst the immature stages of this insect. This considerably reduces the potential damage that the pest can cause. One of the factors contributing towards this loss in numbers is predation by beetles, some of which have been identified by a serological technique as having fed on one or more stages of the root fly (Ann. Rep. 1960, p. 42). Studies were continued on the identity and importance of these predators and also on the effect of soil conditions on the survival of the root fly eggs and larvae.

Field experiments were carried out using barriers which almost entirely excluded carabids but did not exclude staphylinids from the plots, and it was found that carabids were responsible for only a part of the loss of eggs and larvae, thus suggesting that staphylinids, which averaged five adults per plant during the oviposition period of the root fly, were also important predators.

Evidence has been obtained that soil conditions affect survival of the eggs and larvae. Exposure of root fly eggs in the laboratory to different humidities at various temperatures showed that eggs were very sensitive to drying out, especially at higher temperature ranges. There may, therefore, be some mortality from this cause especially when the eggs are near the soil surface. Pot experiments have shown that soil moisture conditions can also affect larval survival, 70 per cent of the larvae becoming established on the test plants in moist soil compared with 30 per cent in drier soil.

It is apparent, therefore, that the survival of the immature stages of the root fly is influenced both by predation and by soil conditions and further studies are in progress to assess their relative importance.

THE CONTROL OF CARROT FLY (D. W. Wright)

Field experiments have shown that when aldrin, dieldrin or lindane are worked into mineral or fen soils, insecticidally active residues remain in these soils for a number of years afterwards. Therefore, when re-treating soils for the control of carrot fly, it has been recommended that only sufficient insecticide should be applied to restore the concentration in the top four inches of soil to its original value (2). The validity of this recommendation for fen soils was tested in an experiment begun in 1956. In that year, aldrin applied at the rate of 2 lb. per acre and worked into fen soil gave 90 per cent control of the carrot fly. No insecticides were applied in subsequent years. In 1957 the control of the pest was much less complete, and from 1958 to 1960 inclusive there was no measurable control of the carrot fly. In early June 1961 half of each of the aldrin plots was re-treated with aldrin and carrots were then sown on all plots. The amounts of residue in the soil before re-treatment were assessed chromatographically and the principal residue found was dieldrin which was present on all plots, including those untreated, to the extent of 0.20-0.25 p.p.m. This had probably come from nearby dieldrin-treated plots in the same experiment by soil having been moved on implements, etc., from plot to plot during six years of cultivations and cropping. Taking into account the greater efficiency of dieldrin compared with aldrin in the control of carrot fly, the dieldrin residue in the soil was estimated to be equivalent to 0.5 p.p.m. of aldrin or approximately $\frac{1}{2}$ lb. aldrin per acre in the top four inches of the soil. To restore the insecticide level in the half-plots to an aldrin equivalent of

approximately 2 lb. per acre, aldrin was worked into the soil at the rate of $1\frac{1}{2}$ lb. per acre. This resulted in a 90 per cent control of carrot fly, the same level of control as that obtained in 1956 when the aldrin was first applied at 2 lb. per acre.

These findings, supported by results obtained from another experiment, indicated that the dieldrin residues in the soil were biologically active even although they themselves had given no measureable control in 1960; and that the amount of residue present should be taken into account when planning further insecticide treatments to avoid the application of unnecessary amounts of insecticide to the soil.

Experiments carried out in 1958, 1959 and 1960 (Ann. Rep. 1960, p. 43), showed that under certain conditions diazinon broadcast and worked into the soil could give a very good control of the carrot fly and that it appeared to persist for only a few months, giving little or no carry-over of diazinon residues from season to season. In 1961, experiments with diazinon were mainly designed to determine the relative effectiveness of different dosage rates of the insecticide when broadcast and worked into the soil as compared with their effectiveness when limited to a narrow band of soil immediately beneath the carrot rows.

In the broadcast experiments the diazinon was used in the form of granules containing three per cent diazinon or in a dilute emulsion in water. After treatment with either formulation, the soil was rotavated twice to a depth of four inches. When applied in early April to fen soil at Mepal, diazinon at either 2 or 3 lb. per acre gave a high control of the first generation of carrot fly on April-sown carrots, but both treatments were much less effective against the second generation attacking carrots sown in May. On mineral soil at Wellesbourne, diazinon was more effective than on the fen soil for controlling the second generation. At 1, 2 and 3 lb. diazinon per acre the percentage of unattacked carrots was 72, 90 and 95, respectively, as compared with 68 per cent unattacked on the untreated plots. As in 1960 there was no difference in the performance of liquid and granular treatments for comparable amounts of insecticide used. These and earlier results showed that diazinon broadcast and worked into the soil at 2 to 3 lb. per acre, when put on in early April was very effective against the first generation—the early crop being harvested before the second generation attack occurred. When applied in late April or early May for the maincrop it gave protection against the first generation attack (if any) but only a partial control of the second generation. With an application in late May or early June for a late crop, which escaped the first generation attack, the diazinon gave very effective control of the second generation.

In the placement experiments where diazinon was limited to a narrow band of soil immediately beneath the carrot rows the insecticide was used only in the granular form. They were drilled into the soil with a V-belt precision seeder, the coulter of which made a one-inch wide channel in the soil and into which the granules were directed. By adjustment of the coulter the granules were put into the soil at depths of $\frac{1}{2}$, 1 and $1\frac{1}{2}$ inches. The carrot seed and granules were drilled together at the $\frac{1}{2}$ -inch depth but at the two lower depths the granules were drilled first and then the carrot seed was sown half-an-inch below the soil surface, and directly above the line of the diazinon granules. At each of the three depths the granules were used at four rates which, based on rows 15 inches apart, corresponded to $\frac{3}{4}$, 1, $1\frac{1}{2}$ and 2 lb. of diazinon per acre. Similar treatments were used at Mepal and Wellesbourne on fen and mineral soils, respectively, and at both places the insecticides were applied and the seed sown in the last week of May. Assessment of treatment effects on carrot samples taken in November showed that in both experiments the depth at which the insecticide had been placed in the soil had no significant effect on its performance against the second generation of the carrot fly. The degree of control, however, increased with increase in the amount of diazinon used. At Wellesbourne, $\frac{3}{4}$, 1, $1\frac{1}{2}$ and 2 lb. of diazinon per acre gave 89.8, 93.1, 98.7 and 97.8 per cent unattacked roots, respectively, as compared with 31.3 per cent unattacked on the untreated plots, the two higher rates of application giving significantly better control than the two lower rates. At Mepal, on fen soil, similar results were obtained with $1\frac{1}{2}$ lb. per acre giving 98.2 per cent unattacked roots, while on the untreated plots 71.8 per cent were unattacked.

The results of these two pairs of experiments indicate that diazinon can be much more efficiently used in the control of carrot fly if limited to the soil beneath the carrot rows than when broadcast and worked into the soil. The under-row placement of diazinon at $1\frac{1}{2}$ lb. per acre gave, on both soil types, a higher level of control than double this amount broadcast and worked into the soil. Tasting tests showed that diazinon broadcast at 2 lb. per acre or under-row placement of diazinon at $1\frac{1}{2}$ lb. and 2 lb. per acre did not affect the flavour of carrots grown in fen soil at Mepal or in mineral soil at Wellesbourne.

BIOASSAY OF INSECTICIDE RESIDUES IN SOILS

(G. A. Wheatley and J. A. Hardman)

It was previously reported (Ann. Rep. 1960, p. 45) that a paper chromatographic technique was being developed which appeared to be more versatile than bioassay methods for detecting and semi-quantitatively estimating residues of chlorinated hydrocarbon insecticides in soils. Moreover, it enabled the identity of the residues to be established with a reasonable degree of certainty. The initial difficulties experienced with the chromatographic method were not associated with the paper chromatography itself but were concerned with the attendant extraction and 'clean-up' procedures which have to be very efficient when residues of less than about 0.1–0.2 p.p.m. are concerned. These difficulties have been overcome and a general method of extraction and 'clean-up' has been developed during the year which is satisfactory for assaying all of the commoner chlorinated hydrocarbon insecticides likely to be encountered at present in soils in the United Kingdom.

The extraction procedure adopted involves a hot, reflux extraction of the soil with acetone, passage of this extract through a cellulose powder column to remove interfering substances, transference of the extracted residues into hexane and subsequent concentration of this hexane extract for spotting on to chromatographic papers which are then developed in a manner similar to that described by Mills (1). The developed spots of the various chlorinated compounds present in a residue are revealed by a colour reaction and they are identified by their R_F values relative to those of standard compounds of known purity. Quantitative estimates are obtained by a photometric method based on the reflection of light from the spots on the chromatograms using known amounts of standard reference compounds for comparison. The limit of detection is about 0.005–0.1 p.p.m. for the following compounds: aldrin, dieldrin, endrin, p, p'-DDT, o,p'-DDT, DDD, DDE, γ -BHC, heptachlor and heptachlor epoxide. Recoveries from 2, 10 and 25 μ g. amounts of aldrin, dieldrin, endrin, p, p'-DDT, γ -BHC and heptachlor added to 50 g. untreated soil before extraction averaged 87 per cent with a standard error of ± 4 per cent. There was no significant difference between the amounts recovered for the six different insecticides and, although the mean percentage recovery for 2 μ g. was slightly less than that for the 25 μ g. amounts, the difference was not statistically significant ($P=0.05$).

The chemical has many advantages over the bioassay method; it is more versatile, more precise and quicker, and it also provides the essential, positive identification of the residues present. In addition, mixtures of most combinations of the above-mentioned compounds can be resolved on the chromatograms so that the method has been found to be of increasing value for assaying samples which contain unknown amounts of several insecticides. Limited use is still being made of the bioassay technique, however, for assaying samples from plots of field experiments of known histories when only single compounds are involved.

A small-scale survey of soils from arable fields known to have been treated with aldrin, either as sprays, dusts or by way of fertilisers containing aldrin, has been initiated in collaboration with the Plant Pathology Laboratory, Harpenden, and the Potato Marketing Board. Residues of chlorinated hydrocarbon insecticides in these soils have been identified and the amounts present estimated by means of the chemical method. As was expected from knowledge of the long-term persistence of these

insecticides in soils, mixtures of insecticides were frequently encountered. The results indicated that the possibility of accumulation of residues following frequent applications of aldrin would originate from the dieldrin formed by epoxidation of some of the aldrin (Ann. Rep. 1960, p. 44), rather than from the aldrin itself, the latter disappearing to a large extent during the first season after application. The compounds most frequently found were dieldrin (formed from aldrin) and the several chemicals present in technical DDT together with the associated degradation product DDE. Several residues of DDT found in soil could be attributed only to the use of sprays on crop foliage.

Micro-plots were installed in the field during the spring of 1961 and it is hoped that these will enable precise studies to be made on the behaviour of insecticides in soils. Experience has been gained in managing the micro-plots during the past summer and their potentialities for this kind of work were investigated. They were used to obtain confirmatory evidence of the aldrin-dieldrin transformation and it was found that 95 per cent of a single application of 1 lb. per acre of pure HHDN (the main active ingredient in aldrin) when left undisturbed on the surface of sandy loam soil disappeared in six weeks during midsummer and gave rise to very little dieldrin. However, when the same quantity of pure HHDN was mixed intimately with the soil, about 40 per cent remained as aldrin and 10 per cent as dieldrin 20 weeks after treatment. This pattern of transformation was not affected to any measurable extent either by fortnightly cultivations, by depth of mixing or by the difference between cropped (carrots) and uncropped soil. The work is continuing and more micro-plots have been installed in order to expand this type of study.

LETTUCE ROOT APHID (J. A. Dunn and Jean Kirkley)

The low incidence of lettuce root aphid in 1960 was followed by very small numbers of galls on poplar in the spring of 1961 and only a few winged, migrant root aphids were recorded on lettuce in June and July.

Experimental plots in 1961 included those treated with endrin in 1960 and these were again sown with lettuce without any more insecticide being applied. Although the root aphid infestation was light, there was a significantly lower percentage of attacked plants on plots which had been treated in 1960 with 2, 1 and $\frac{1}{2}$ lb. of endrin per acre, than on those which were not treated or had received only $\frac{1}{4}$ lb. of the insecticide per acre. This indicated that endrin residues may persist in the soil for a long time. A paper chromatographic method was used to examine the foliage of lettuce grown in soil which had received a pre-sowing treatment of up to 2 lb. of endrin per acre. No residues were found and it was concluded that if any endrin was present in the foliage it was at a concentration of less than 0.02 p.p.m.

Pre-sowing soil treatments using endrin, diazinon and thiodan at rates of 2, 1, $\frac{1}{2}$ and $\frac{1}{4}$ lb. of the active ingredients per acre were tested in another field experiment. None of these treatments affected crop growth but the attack of lettuce root aphid was too low to assess their relative effectiveness against the pest.

CARROT-WILLOW APHID (J. A. Dunn and Jean Kirkley)

The most remarkable feature about the carrot-willow aphid in 1961 was the rapid build-up in its numbers during spring and early summer. Following a season of low aphid numbers, few eggs were laid on willows in the autumn of 1960 and in the following spring only small numbers of aphids could at first be found on willows. However, prolonged periods of dry, anticyclonic weather during April, May and June favoured aphid development and multiplication and, in an environment that was largely free of natural enemies, the carrot-willow aphid increased in numbers with extreme rapidity.

The first winged forms were found on early-sown carrots at Wellesbourne on 12th May and from then onwards the numbers arriving increased and reached a maximum in the first week of June. Very large populations of winged and wingless

aphids developed on carrots and were most abundant there during late June and early July. From this time onwards their numbers declined sharply, the depletion being speeded by emigration of winged forms and by a heavy attack of parasites. Many possible umbelliferous hosts, both cultivated and wild, were grown on field plots at Wellesbourne. Chervil, wild carrot, dill and parsley were all heavily attacked by the aphid but coriander and wild hemlock remained uncolonised throughout the season.

The heavy aphid attack caused widespread and severe damage on carrots particularly on the early and mid-season crops. Celery was also attacked but its growth was less affected. Late-sown carrots, however, largely escaped aphid attack and produced normal crops. Demeton-methyl, malathion and menazon were used against this aphid in a replicated field experiment with carrots sown on 17th April 1961 at Wellesbourne. One application of demeton-methyl at 8 oz. of toxicant per acre gave a high level of aphid control when applied on 15th May to carrots at the first true leaf stage and when the winged aphids had begun to infest them. A slightly better control was given when a similar, single application of demeton-methyl was made two weeks later. The best control was obtained, however, where the carrots were sprayed twice—at the first true leaf stage and two weeks later—and a 79 per cent increase in the marketable crop yield resulted. Malathion reduced the numbers of winged forms only on the day of application and failed to protect the carrots against further aphid influxes. Carrots sprayed twice with malathion subsequently became very heavily infested and the aphid populations and crop yields recorded were not different from those of untreated carrots. Menazon used as a seed dressing and as pre-sowing soil treatments also gave little or no control of the aphids, the insecticide appearing to have lost its effectiveness in the soil between sowing and the time of appearance of aphids on the crop, a period of about one month.

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PLANT PATHOLOGY

By W. G. KEYWORTH

Over the past year the extent of research on certain diseases has been reduced, either because suitable control measures have been devised or because the immediate objectives of the work have been reached. Thus, although limited research on these diseases was continued, it has been possible to start new projects. The diseases receiving less attention than hitherto are silvering of beet, *Didymella* stem rot of tomato, powdery mildews, and watercress crook root. New projects, brief notes on some of which are given below, are on downy mildews and wilt diseases of various crops, celery crater spot, and carrot motley dwarf disease.

CROOK ROOT OF WATERCRESS (J. A. Tomlinson and R. G. Garrett)

Studies were continued on the use of zinc frit or zinc sulphate for control of the disease.

(i) *Zinc frit*

The 1959-60 trials (Ann. Rep. 1960, p. 47) showed that a new type of zinc frit controlled the disease throughout cress beds if applied to the top 25 yd. only, at 5 oz. per sq. yd. In the 1960-61 experiments this frit was tested at reduced rates and gave good control at 4 oz. and 3 oz. per sq. yd., but not at 2 oz. and 1 oz. per sq. yd. Although conditions vary widely in different commercial beds, particularly in respect of water flow, it seems likely that an application of 3-5 oz. per sq. yd. to the top 25 yd. of most commercial beds would be effective.

Applications of 2-4 oz. per sq. yd. gave no phytotoxic effects but 5 oz. per sq. yd. induced a slight and temporary yellowing and stunting of the plants in the treated area. This stunting was not increased if the area had received the same dose in the previous season.

(ii) *Zinc sulphate*

In collaboration with the N.A.A.S., experiments were made on farms in several areas to study the effect of drip-feeding zinc sulphate into the main water supply of the cress beds. The water flow was measured by means of graduated weirs and the zinc sulphate was applied from an apparatus giving a constant amount of solution.

In one experiment at Alresford, Hampshire, the zinc content of the water in one group of beds was raised to 0.1 p.p.m. for two months, at the end of which time (late November) crook root infection was 0.1 per cent, compared with 24.1 per cent in an adjacent group of untreated beds. The zinc content was then lowered to 0.05 p.p.m. for three months. Crook root infection was then 1.1 per cent, while that in the untreated beds had risen to 76.5 per cent.

On most other farms it was not possible to have untreated control beds but, when the water supply was treated to give zinc contents of 0.1 to 0.05 p.p.m., beds in which the disease had been severe in previous years were almost free from infection throughout the trials. No phytotoxic effects were produced by any of the treatments and the zinc content of representative samples of cress was less than 22 p.p.m.

The standard drip feed apparatus has been described (3) and is now commercially available to growers through the N.F.U. Watercress Branch.

PARSNIP CANKER (A. G. Channon)

Investigation of the effects of sowing date and singling distance was continued in 1960-61. Parsnips were sown on 21st March and 24th May 1960 at a row spacing of 12 inches and were singled to 3-inch and 6-inch intervals. The summer and autumn of 1960 were wet and black canker predominated and developed early. In field harvestings from October to January, canker was least on the May-sown roots singled to 3-inch and 6-inch intervals, but the highest marketable yield was obtained from the crop sown in March and singled to 3-inch intervals.

In further studies on the importance of leaf infection by *Itersonilia*, a significant reduction in the number of roots showing black canker in November was obtained where the foliage had been removed in September; a slight reduction in root size may have accounted for part of this decrease in disease. Greater reductions both in the numbers of diseased roots and in the lesion size were obtained when 4-inch high soil or peat ridges were maintained over the roots from August onwards. The trapping of airborne spores of *Itersonilia* on exposed Petri dishes in a parsnip crop was continued.

In small scale trials at Wellesbourne of resistant parsnips, made in collaboration with the Plant Breeding Section, a number of lines showed high resistance to both black and orange-brown canker.

CLUBROOT OF BRASSICAS (A. G. Channon and R. A. L. Hinton)

In former tests of the effects of aldrin on clubroot, commercial formulations were used (2). Such formulations contained many additives and impurities as well as the active ingredient (HHDN) and, therefore, the possibility remained that these impurities might have been responsible for the reductions in clubroot obtained with the commercial formulations. To test this, pot experiments were carried out in 1961 using specially prepared dusts containing either technical aldrin or pure HHDN together with an inert filler. These experiments showed that the pure compound gave a reduction of clubroot similar to that obtained with the technical aldrin and it is probable, therefore, that HHDN is the effective constituent of the commercial preparations.

In further studies of cabbages bred for resistance to clubroot, some disparity was shown between the results of preliminary glasshouse tests of young plants and those of subsequent field trials with the same plants. Thus although three lines raised from German stock were moderately infected after seven weeks in the glasshouse, the final disease intensity on the plants after a further ten weeks in the field was less than on three American lines which showed only slight infection in the preliminary glasshouse test. The causes of this effect are being studied.

LEAF AND POD SPOT OF PEAS (R. B. Maude)

In further tests of the control of *Mycosphaerella* infection of pea seed by soaking the seed in various fungicides, extended growth tests of the resulting plants were made in sterilised grit and in field soil. Twenty-four hours soak in 0.2 per cent water suspensions of captan or thiram at 30°C. continued to give good control of the disease, although some delayed infection of up to 3 per cent appeared after 42 days and none of the treatments gave complete eradication of the disease.

Captan caused some suppression of germination under unsterile soil conditions but thiram did not. When treated seed was redried and stored there was little or no loss in viability.

In other experiments, seed was treated at 70°C. for three hours in carbon tetrachloride containing one per cent of captan or thiram. Both treatments, measured over a period of 42 days, reduced infection to 0-2 per cent (controls 36 per cent) and were an improvement on treatment at 70°C. in carbon tetrachloride without the fungicide (16 per cent infection). In addition, there was very little loss in viability.

BIG VEIN DISEASE OF LETTUCE (J. A. Tomlinson and R. G. Garrett)

As previously reported (Ann. Rep. 1960, p. 49), an *Olpidium* sp. was found in the roots of a healthy lettuce plant. Other similar isolates have since been obtained which readily infected lettuce roots but failed to cause any symptoms of big vein on the leaves. The morphology and host range of these isolates were indistinguishable from those which induce the disease. The causes of the different effects of the two types of *Olpidium* are now being studied.

Symptoms of big vein have been induced on healthy plants by grafting them with scions from plants affected with the disease. In a series of experiments, 22 of 74 plants grafted in this way developed symptoms, whereas none of 70 control plants did so. No *Olpidium* could be found in the roots of any of the plants. It thus appears that the agent immediately causing symptoms can be graft-transmitted. Details of this work have been published (5).

LETTUCE MOSAIC DISEASE (J. A. Tomlinson)

The major part of the work on this disease has been on the purification of the causal virus, partly with the object of obtaining an antiserum, the use of which would enable the disease to be identified quickly and with certainty.

Using a modification of the method devised for the purification of cucumber mosaic virus (6) highly purified preparations of lettuce mosaic virus were obtained. After injection into rabbits these gave an antiserum which has been accumulated in sufficient quantity for future use. Tests already made have shown that it reacts specifically with sap from infected plants. The purified virus itself is also of considerable value for infection studies on alternative hosts and in the assessment of disease resistance. A brief description of the purification method has been published (4).

WILT DISEASES OF PEAS, BEANS AND TOMATOES

(W. G. Keyworth, Jane Britton and Judith M. Dow)

In a general study of wilt diseases, experiments have been made on the *Fusarium* wilts of peas and beans, and on the *Fusarium* and *Verticillium* wilts of tomatoes. Methods of testing varieties for resistance in the glasshouse have been studied and, contrary to previously published information (1), it appears likely that the infection of peas by dipping their roots in mycelial suspensions of the appropriate race of *Fusarium oxysporum* f. *pisi* will enable varietal resistance to be assessed adequately. Similar methods have been used with runner beans and climbing French beans. No resistance to *Fusarium* wilt was found in any of the varieties of runner bean tested but some lines of Blue Lake climbing bean proved to be highly resistant to the disease.

Grafting experiments on the mechanism of resistance of tomatoes to *Fusarium* and *Verticillium* wilts have provided information on the differential reaction of stems and roots to infection.

CRATER SPOT OF CELERY (W. G. Keyworth and Judith M. Dow)

Studies have been started on this disease which causes sunken brown lesions on the leaf stalks of celery and is particularly troublesome in certain areas of the fens.

It has proved to be very difficult to establish the cause of the disease but isolations from affected tissue have occasionally yielded species of *Botrytis* and *Rhizoctonia*. When inoculated into plants, both fungi have caused lesions, but it seems most likely that *Rhizoctonia* is the primary pathogen.

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WEED INVESTIGATIONS

By H. A. ROBERTS

ECOLOGY (Sheelagh M. S. Hird, F. Gillian Stokes and H. A. Roberts)

In autumn 1959, samples were taken from the plots of three long-term field experiments in Soakwaters (Ann. Rep. 1954, p. 37) to determine the cumulative effects of the cropping and treatments on the numbers of weed seeds present in the soil at the end of the second three-year cycle of the rotation. The samples were kept for two years and the numbers of seedlings which emerged were recorded as previously described (1). The results obtained for the cultivation experiment show that during 1959, on two phases there was an appreciable reduction in the numbers of viable seeds present in the top six inches of soil compared with those recorded after the wet season of 1958 when seeding of weeds could not be prevented. On the third phase, the numbers of seeds of some species were less, but other species were able to produce seed in the spring cabbage crop, so that the overall reduction was comparatively slight. The figures obtained for the nitrogen and the NPK experiments were similar to those for the first two phases of the cultivation experiment, with an average of approximately 13 million seeds per acre. On the phase of the NPK experiment which carried spring cabbage during the winter of 1958-59, however, twice this number was recorded.

The main conclusions from the six-year study may be summarised as follows. Under conditions of frequent cultivation, and in the absence of any appreciable weed seed production, the total population of viable weed seeds in the soil tended to fall at a constant rate, such that the number of seeds present in any one year was approximately 50 per cent of that in the previous year; i.e., the 'half-life' of the population was one year. Comparison with published results of other workers regarding the effect of fallowing on weed seed populations in the soil suggests that the estimate of the rate of reduction obtained in the present work may be of more general application to mixed populations of weed seeds comprising a range of species.

Of the four primary cultivation treatments included in the cultivation experiment, deep ploughing and shallow ploughing with subsoiling gave very similar results. In each of the six years, the mean weed seed populations of plots receiving these two treatments were almost identical. Shallow ploughing also resulted in populations little different from those on the deeply-worked plots, although following occasions when weed seed production occurred, greater numbers of seeds were recorded in the top six inches of soil on the shallow-ploughed plots.

The fourth treatment, shallow rotary cultivation, gave somewhat different results. It was found that after occasions when seeding of weeds had occurred, the increases in the numbers of seeds in the soil were greater on the rotary-cultivated plots than on those that had been ploughed, leading to higher weed stands in subsequent crops. Many of the species present made little contribution to this difference, but it was especially marked with annual meadow grass (*Poa annua*), chickweed (*Stellaria media*), groundsel (*Senecio vulgaris*), shepherd's purse (*Capsella bursa-pastoris*), and speedwell (*Veronica persica*). The results as a whole indicate that where a high standard of cleanliness can be maintained, the type of primary cultivation employed is relatively unimportant so far as the numbers of weed seeds in the soil are concerned. If, however, the production of weed seeds unavoidably occurs from time to time, the continued use of the rotary cultivator for primary cultivation is more likely to result in a rapid build-up of seed populations of particular weed species than the continued use of the plough.

It appears that the standard of cleanliness maintained in these experiments was sufficient to mask any differential effects on the numbers of weed seeds of the various

organic and inorganic manurial treatments. Comparison of the results from plots which received FYM at the rate of 20 tons per acre before each crop over a period of six years with those from plots which received none, revealed no consistent differences either in the total numbers of weed seeds present or in those of individual species, and it is evident that no significant numbers of weed seeds were introduced with the FYM used.

In these experiments it has not been possible to determine how much of the observed general decrease in weed seed numbers from 1953 to 1959 was due to loss of viability of the seeds remaining in the soil, and how much was due to germination and subsequent destruction of the seedlings by the frequent surface cultivations. In order to distinguish between the two factors and to assess their relative importance, an experiment has been started incorporating three frequencies of cultivation in which records are being taken both of the numbers of viable seeds in the soil and of the numbers of seedlings which emerge.

CHEMICAL CONTROL (H. A. Roberts and B. J. Wilson)

Three further field experiments were conducted to determine the response of spring-sown broad beans to pre-emergence applications of several residual herbicides and the results, together with those of previous experiments, have been written up for publication. Of the herbicides at present available commercially, the best results were given by simazine 0.75 lb. per acre, chlorpropham 1 lb. plus diuron 0.2 lb. per acre and dinoseb-amine 3-4 lb. per acre, all applied as high-volume sprays shortly after sowing. The 1961 results confirmed those of previous years in showing that the inclusion of fenuron instead of diuron in mixtures with chlorpropham caused greater crop injury, and it appears that on light soils the use of fenuron would entail a risk of yield depression if heavy rainfall occurred in the period between application and crop emergence.

Further work was carried out to assess the potentialities of amiben for selective weed control in vegetable crops. In 1960, under relatively dry conditions, amiben gave good results as a residual pre-emergence treatment for large-seeded legumes, but it was emphasised (Ann. Rep. 1960, p. 55) that further experience under conditions of higher rainfall would be required before conclusions regarding crop safety could be reached. Such conditions were encountered in the spring of 1961, when it was found that even the comparatively low rate of 2 lb. per acre resulted in severe injury to broad beans, and peas and dwarf French beans were also adversely affected. The degree of weed control achieved was less than that in 1960, with annual meadow grass and fumitory (*Fumaria officinalis*) proving especially tolerant, and the results suggest that there was considerable downward movement of amiben in the soil under the influence of rainfall. It would appear, therefore, that on light soils, amiben is unsuitable for pre-emergence use in large-seeded leguminous crops.

The umbelliferous crops, on the other hand, appear to show a marked degree of inherent tolerance to amiben, and at rates of up to 4 lb. per acre there was no adverse effect on the yield of carrots, parsley and parsnips. In these crops the variable weed control would seem to be the limiting factor. Further trials with a granular formulation of amiben applied after transplanting brassica crops indicated that the risk of crop damage was too great, and when used as a pre-emergence treatment on drilled lettuce, both amiben and the related compound dinoben caused a severe check to crop growth.

Two chloro-substituted triazines, trietazine and propazine, were again included in field experiments with various crops. Trietazine at 1.5 lb. per acre gave excellent results as a pre-emergence spray in spring-sown broad beans. Although less effective than simazine against weeds, in that approximately twice the amount was required to achieve the same result, trietazine showed greater selectivity. Good results were also obtained in peas, but trietazine appeared to be unsafe for use in dwarf French beans, since the yield was significantly reduced by a rate of 1 lb. per acre. As in previous

years, propazine at 0.5 lb. per acre gave excellent weed control in carrots, parsley and parsnips, with only temporary crop injury.

Prometryne, a methyl-mercapto triazine, was compared with propazine in several experiments with umbelliferous crops. When used as a residual pre-emergence treatment it proved less effective than propazine, but caused less crop injury at equivalent rates of application. Promising results were also obtained with pre-emergence sprays of prometryne in large-seeded legumes. In addition to residual activity, prometryne is active through the foliage, and in tests in which it was applied as a post-emergence spray, carrots, parsley and parsnips showed an appreciable degree of tolerance to rates which gave excellent weed control.

Further experiments with drilled onions confirmed that on the light Wellesbourne soil the use of chlorpropham at more than 0.75 lb. per acre as a pre-emergence treatment entails a risk of severe crop damage if application is followed by heavy rain. In an experiment with planted onion sets, however, both chlorpropham and chlorpropham plus diuron gave excellent results. Chlorpropham also gave effective control of susceptible weed species when applied to drilled lettuce, and had no adverse effect on crop yield and maturity.

In several experiments, with chlorpropham, amiben, dinoben and dinoseb-amine, comparisons were made of liquid and granular formulations. In general, when applied at equal rates of active ingredient, the granular formulations tended to give slightly poorer weed control than the corresponding sprays, but there were no marked differences in crop growth and yield. Experiments were also carried out, both in the field and in the glasshouse, with several other residual herbicides in order to determine crop tolerance.

Work on the disappearance of chlorpropham residues under field conditions was continued, using the bioassay technique previously mentioned (Ann. Rep. 1960, p. 55), and a description of the method and of the results obtained has been prepared for publication. From a series of applications of 1 or 2 lb. per acre made at different times of the year it was found that loss of phytotoxic activity was most rapid under conditions of summer temperature and adequate soil moisture, when 90 per cent of the amount applied disappeared in less than four weeks. When applied during winter, residues of chlorpropham persisted for more than three months. The results suggest that for applications made during the growing season, the average period required for 90 per cent disappearance would be six to eight weeks.

SPRAY DRIFT (J. M. Way)

During 1961, experiments were carried out in the field and glasshouse in which vegetable crops were treated with sub-lethal doses of growth-regulators in order to amplify the descriptions and photographic records of plant responses which were obtained previously. An annotated series of colour transparencies illustrating the main morphological abnormalities induced by MCPA and related compounds has been prepared.

Further glasshouse experiments have been conducted with MCPA to study the development of the characteristic leaf abnormalities shown by lettuce, and material has been obtained for a histological examination of affected leaves. The effect of application of MCPA in large (500 μ) and small (70 μ) droplets to lettuce has also been studied.

Acknowledgment

The assistance of various firms in supplying samples of herbicides for experimental use is gratefully acknowledged.

REFERENCE

- (1) ROBERTS, H. A. (1958). Studies on the weeds of vegetable crops. I. Initial effects of cropping on the weed seeds in the soil. *J. Ecol.*, **46**, 759-68.

STATISTICS REPORT

By J. A. NELDER

The advisory side of the Section's work produced the usual diverse crop of problems in the design and analysis of experiments and the construction of quantitative models for various phenomena. Some of the non-routine problems which required detailed study are described below.

Field experiments (J. A. Nelder, G. Berry and R. Mead)

Striking edge effects are often seen on experimental plots of red beet, and a preliminary investigation of this effect was made in 1961. Isolated square plots of sizes 2, 6 and 18 feet, and rectangular plots of sizes 18×2 ft. and 18×6 ft. were sown with beet to give average spacings of 4 inches and 12 inches square per plant. The plots were harvested in bands of width 4 and 12 inches, respectively, starting from the outside of the plots and working inwards. The two densities gave markedly different results; at 4 inches square the outside band of plants gave roots 3.6 times the weight of the interior plants, and for the second band the figure was 1.69. (The very small plots are excluded in deriving these figures). From the third band inwards there was no apparent trend. For plants spaced at 12 inches square only the outside band was different from the remainder and then only some 14 per cent above the interior. The interiors of all plots gave very similarly sized plants except those of the very small (2×2 ft.) plots, which gave larger plants than the remainder at both densities. The results showed that all plots longer than 6 feet and wider than 2 feet would give yields free of edge effects if one foot was discarded round the plot before harvesting.

An attempt to break down the variability in carrot root sizes at harvest was made in an experiment where seed size, density and germination time were the factors under test. Seed of three sizes and also the natural mixture were used, at two densities. The effect of germination time was measured by three treatments; in one (E_1) the first third of the seedlings were marked on emergence and retained while the remainder were pulled out. In the second (E_2) the last third of the seedlings were retained, and the remainder discarded giving a mean emergence date three days later than E_1 . In E_3 all seedlings were left but the first third were marked with wire so that they could be identified at harvest. Some overall thinning was done after emergence ceased, to equalise densities where necessary. The results were both surprising and disappointing. Seed size had no effect on yield or on the variability of root size within a plot. The density effect was as expected; a higher yield from the higher density (plants per sq. ft.) and the same percentage standard error for both densities for variability of root size within plots. Of the E treatments, E_2 gave larger carrots than E_1 or E_3 which was unexpected, and the variability of root size in E_1 and E_2 , which had fairly uniform germination times, was just as great as in E_3 which had a more widely spread one. Thus none of the factors tested had any marked effect on the variability of root size as measured by the percentage standard error, and the reasons for this variability must presumably be sought elsewhere.

Yield-density relations (J. A. Nelder)

The equation suggested in (1) for the relation between yield per plant and density where the pattern of arrangement is held constant has been found to hold for several new sets of data on a variety of crops. Possible extensions of the relation to cope with differing pattern of arrangement as well as density have been investigated, and compared with actual data. One model which appears to fit some existing data quite well,

predicts an unexpected phenomenon, namely, that small deviations from squareness of arrangement (i.e., inter-row distance=intra-row distance) may produce marked reductions in yield. The reasons for this are not at all clear, but may be due to deficiencies in the model or in the data used for testing it, where perhaps some factor, such as weed control, had not been exercised equally at all densities.

In collaboration with the Plant Physiology Section a competition experiment was carried out in seed boxes, using cabbage and buckwheat as the two species. A model in which a negative power of the weight per plant is expressed as a bilinear form in powers of the densities of the two species was tested and found to give a reasonable fit to the data. The species chosen proved to be of different growth types. The total weight of buckwheat per unit area reached a plateau as crop density increased, while the total weight per unit area of cabbage reached a maximum and then declined with increasing crop density. It was encouraging that two of the parameters fitted for the cabbage yields were similar in size to those found from a field crop allowed to grow to maturity.

A description of some new systematic designs for spacing experiments, together with instructions for their construction in the field, has been submitted for publication. R. Mead has co-operated in writing and testing several computer programmes using Mercury Autocode for the fitting of the non-linear equations used for various yield-density relations involving one and two species.

Other work

G. Berry has studied the variability in maturity of peas within loads arriving at several canneries with a view to recommending a sampling scheme which will be adequate to assess the mean maturity of a given number of loads with a minimum pre-determined error. He has also begun a study of the problem of fitting a common response surface for several experiments when the relative, but not the absolute, levels of the experimental factors are known. Nelder and Berry have written a computer programme for the fitting of one non-linear parameter in an otherwise linear situation, using a search procedure to find the position of the minimum residual sum of squares. Nelder has also written a programme to fit the generalised logistic equation to growth data using the methods described in (2). Mead has begun a study of the size-grade distributions in carrot crops and their relation to density, time of harvest, etc. He has also investigated the edge effects in a broad bean experiment carried out by the Weeds Section.

Work for other bodies

Analyses for the N.A.A.S. involved 33 experiments with 2,574 plots in all, each analysis comprising an average of 3.6 variates.

Acknowledgment

The help of Mr. J. H. A. Dunwoody in putting routine analyses through the Rothamsted Elliott 401 computer is gratefully acknowledged.

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- (1) BLEASDALE, J. K. A. and NELDER, J. A. (1960). Plant population and crop yield. *Nature, Lond.*, **188**, 342.
- (2) NELDER, J. A. (1961). The fitting of a generalisation of the logistic curve. *Biometrics* **17**, 89-110.

THE WEATHER DURING 1961

RECORDS OF THE N.V.R.S. AGRO-MET. STATION

By CHRISTINE DOWN, E. J. WINTER, and R. B. AUSTIN

The wet autumn and winter of 1960-61 caused waterlogged conditions in heavy poorly drained land, e.g., Soakwaters, where March cultivations and planting operations were difficult to carry out. In general, however, the weather during 1961 was favourable for farming and horticulture on most soils. Light rainfall during the early months enabled cultivations and sowing to be carried out without delays, while three inches of rainfall in April provided ample soil moisture for germination. Harvesting suffered little interference from rain.

The weather records for 1961 are summarised in Tables I and II, and those for the winter of 1960-61 are included in Table I.

Total rainfall during 1961 was 21.52 inches—three inches less than the 11-year average, and the total number of hours of sunshine was about 7 per cent more than the average. The early spring was exceptionally mild and there were no air frosts in April. On 27th and 28th May, however, widespread frost occurred which, although the air temperature fell only two to three degrees below freezing point, damaged crops such as runner beans and potatoes, especially in low-lying areas.

Reference to the monthly rainfall and evaporation totals shows that a considerable soil moisture deficit occurred during each of the summer months, so that non-irrigated crops would be expected to have suffered from moisture stress.

The following figures show the 1961 rainfall at the N.V.R.S. Sub-Station at Paglesham, measured by Mr. McVittie:—

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total inches
1.96	2.19	0.16	1.47	1.34	1.43	1.04	1.29	1.69	2.36	2.42	3.25	20.60

TABLE I

Summary of various weather features during 1961

				*11-year average
Sunshine:	sunniest month	...	June (daily average 7.54 hours)	6.2 hours.
	dullest month	...	January (daily average 1.22 hours)	1.5 hours.
	most in a day	...	14.4 hours on 29th June (86% of possible).	
Rainfall:	wettest month	...	December (3.48 inches)	2.35 inches.
	driest month	...	March (0.08 inches)	1.52 inches.
	most in a day	...	1.15 inches on 12th June	
	total during 1961	...	21.52 inches	24.55 inches.
Wind:	windiest month	...	February (daily average run—153 miles)	135 miles.
	calmest month	...	April	130 miles.
			December (daily average run—106 miles)	135 miles.
	windiest day	...	18th October (day's run—375 miles)	
	calmest day	...	21st December (day's run—16 miles)	
	daily average run of wind during 1961—125 miles.			
Air temperature:				
	warmest month	...	61°F. mean temperature in August 61°F. (10-year average)	
	coldest month	...	35°F. mean temperature in December 40°F. (10-year average)	
	highest maximum	...	88°F. on 29th August.	
During winter 1960-61:				
	lowest minimum	...	26°F. on 13th and 14th December 1960, 11th, 12th January and 20th March 1961, i.e., 6° of frost.	
	first air frost	...	29°F. on 13th October 1960.	
	last air frost	...	31°F. on 28th May 1961.	
	number of nights with air frost—52			68
	number of nights with ground frost—106			102

*The averages refer to the corresponding month or period during the previous 11 years. Thus, in the first entry in the table, the average daily number of hours of sunshine for June during the past 11 years was 6.2, but June was not necessarily the sunniest month in every year.

TABLE II
Observations made at N.V.R.S. Agro-Met. Station during 1961

Month	Air temperature °F.		Number of frosts		Mean soil temperature °F. at 0900 hr. G.M.T.			Rainfall		Total sun hours	Mean daily solar radiation gm. calories	Mean daily run of wind Miles	Evaporation from water surface Total inches
	Mean Max.	Mean Min.	Air	Ground	4"	12"	48"	Total inches	Number of days with rain				
January	43	33	14	22	36.1	38.0	41.7	1.89	19	37.9	42	151	0.22
February	50	39	2	10	41.6	42.9	43.4	1.72	15	66.6	88	153	0.26
March	56	36	11	20	42.9	44.9	45.5	0.08	4	154.9	223	124	1.34
April	57	43	0	5	49.9	50.1	—	3.16	20	80.0	211	106	1.27
May	61	42	2	9	55.7	—	53.0	0.73	7	198.0	371	113	3.39
June	69	48	0	3	63.0	60.8	56.7	1.49	5	226.3	455	110	4.13
July	69	51	0	1	63.1	62.5	60.2	1.48	9	177.6	389	114	4.06
August	70	52	0	0	60.9	61.1	59.9	1.42	13	177.7	329	144	3.65
September	68	51	0	2	58.7	60.6	60.0	3.16	11	129.4	233	112	2.11
October	58	44	2	5	49.1	53.4	56.0	1.69	19	124.9	149	143	1.20
November	48	36	12	15	40.8	44.7	49.2	1.22	13	65.7	74	127	0.34
December	40	30	20	24	35.5	38.9	4.1	3.48	14	62.6	53	106	0.06
Total 1961	—	—	63	116	—	—	—	21.52	149	1501.6	—	—	22.03
11-year average	—	—	—	—	—	—	—	24.55	170	1405.1	—	—	—

LIBRARY REPORT

By D. A. WOODROFFE

Library usage has been maintained at a high level during the year, and the library stock in all categories has increased. Three new journals were taken during the year—Crop Science, Horticultural Research and Weed Research—while many other new periodicals have been obtained in exchange for the N.V.R.S. Annual Report, bringing the total for current periodicals received to 194. Annual Reports are exchanged with many research stations in the United Kingdom, and also with research centres in 29 other countries.

Requests for the purchase of books for the library have been received from all Research Sections and, after consideration by the Library Committee, 56 books were bought.

One hundred complete volumes of journals were bound during the year, and 1,014 bound periodical volumes are now held by the library.

Requests from staff to borrow material not held at the N.V.R.S. have continued to increase in number, and 264 items have been borrowed from other libraries during the year. Loans to other libraries from N.V.R.S. holdings totalled 20.

A list of 'Books added to the library' is now produced, and is circulated to libraries covering similar fields to the N.V.R.S. library. It is expected that this will lead to an increase in external loan requests for books, previous loans having consisted mainly of back numbers of periodicals.

An author card catalogue is being compiled which will eventually cover all books, bulletins, reprints and other miscellaneous items held by the library.

The N.V.R.S. Association has generously agreed to provide funds for the purchase of historical books on horticulture, particularly vegetable growing, for the library. In this way it should be possible for a useful and interesting collection of these older books to be assembled, and the following books have already been purchased:—

AMHERST, Alicia. A history of gardening in England.

2nd edition. London, 1896.

COBBETT, William. The English Gardener. London, 1845.

MAWE, Thomas and ABERCROMBIE, John. Every man his own gardener. 7th edition. London, 1776.

Several books, etc., have also been kindly presented to the library during the year. Mr. J. V. Cole of Newquay has given four books, Professor T. Wallace and Mr. D. Harknett of Tottenham have each given one book, Miss K. H. Coward of North Finchley has given three volumes of The Gardeners' Magazine of Botany, 1850–51, and Dr. Alexander Nelson has again given various periodical parts and other reprints. Sincere thanks are expressed to each of these donors, and also to members of staff for adding other items to the library.

PUBLICATION RECORD

BLEASDALE, J. K. A. and NELDER, J. A. (1960). Plant population and crop yield. *Nature, Lond.*, **188**, 342.

(Attention is drawn to mathematical models proposed by Japanese workers for density/yield relationships. A modification of their latest equation is proposed which has been found to give a better fit to data from some spacing experiments).

BLEASDALE, J. K. A., HAWORTH, F., WRIGHT, D. W. and WHEATLEY, G. A. (1961). Studies on carrots. *J. R. hort. Soc.*, **86**, 222-5.

(An outline of the results of work done at Wellesbourne on the spacing and manuring of carrots and on the control of carrot fly).

DUNN, J. A. (1960). The formation of galls by some species of *Pemphigus* (Homoptera: Aphididae). *Marcellia*, **30**, 155-67.

(The method whereby the fundatrices of certain species of *Pemphigus* form their galls on *Populus nigra* var. *italica* is described, together with the possible mode of action of the substance which, when injected into the plant tissue by the insect, causes gall formation).

GREENWOOD, D. J. (1961). The effect of oxygen concentration on the decomposition of organic materials in soil. *Plant and Soil*, **14**, 360-76.

(In soils of widely different types the respiration was not inhibited and the anaerobic decomposition of organic materials was not induced unless the concentration of oxygen in the water at the surfaces of the micro-organisms was less than about 1/100 of that in an air saturated aqueous solution. These facts are used to deduce and test experimentally a theory for the distribution of oxygen in soil crumbs).

HAWORTH, F. (1961). The effects of organic and inorganic nitrogen fertilisers on the yield of early potatoes, spring cabbage, leeks and summer cabbage. *J. hort. Sci.*, **36**, 202-15.

(The yield responses at Wellesbourne for the years 1954-59 are described).

HAWORTH, F. (1961). Physical conditions of soil. *Nature, Lond.*, **190**, 221-2.

(A brief review is given of work in progress on the effects of soil physical conditions on plant growth).

KEYWORTH, W. G. and DOW, J. M. (1961). The control of damping off and wirestem of brassica seedlings caused by *Rhizoctonia solani* Kuhn. *Rep. nat. Veg. Res. Sta. Wellesbourne for 1960*, 51-4.

KEYWORTH, W. G. and HOWELL, J. S. (1961). Studies on silvering disease of red beet. *Ann. appl. Biol.*, **49**, 173-94.

(Studies extending from 1952-59 are described. The disease, which was responsible for severe losses in seed crops of the variety Cheltenham Green Top, was found to be caused by a bacterium which was transmitted in the seed. Spread occurred among the seedlings during the winter, giving rise to severe outbreaks in the maturing crop. The bacterium was almost completely eradicated from seed by treating it with 200 p.p.m. streptomycin, and commercial tests demonstrated that this treatment gave a practical control of the disease).

NELDER, J. A. (1961). The fitting of a generalisation of the logistic curve. *Biometrics*, **17**, 89-110.

(Describes the fitting to growth data of the family of curves defined by the differential equation

$$\frac{dW}{dt} = kW \left[1 - (W/A)^{1/\theta} \right]$$

NELDER, J. A. (1961). A note on some growth patterns in a simple theoretical organism. *Biometrics*, **17**, 220-8.

(Gives a revised formulation of the differential equations for the behaviour of a system of two linked enzymes suggested by Hinshelwood, together with the exact solutions when the system is disturbed in various ways).

ROBERTS, H. A. (1960). Weed control with dinoseb (amine) in runner and French beans. *J. hort. Sci.*, **35**, 266-74.

(Twelve field experiments were conducted in which dinoseb (amine) was applied as a residual pre-emergence spray for the control of annual weeds in runner and French beans. When applied at the rate of 3-4 lb. per acre, either as a band or overall treatment, good weed control without crop damage was obtained).

ROBERTS, H. A. and WILSON, B. J. (1961). The response of vegetable crops to pre-emergence applications of some substituted triazines. *Proc. fifth Brit. Weed Control Conf.* 1960, 409-12.

(The response of twelve vegetable crops to simazine, propazine, trietazine and atrazine was determined in field and glasshouse experiments. The most promising treatments were propazine on carrots, propazine and trietazine on parsnips and parsley, trietazine on peas, and simazine and trietazine on broad beans).

SALTER, P. J. (1960). Effects of different soil moisture conditions during the seedling stage on the growth and yield of early summer cauliflowers. *J. hort. Sci.*, **35**, 239-48.

(The response of early summer cauliflower plants to wet or dry soil moisture conditions during the early stages of growth was determined in three successive seasons. The treatments were applied to potted plants in cold frames from October to March. The wet treatment resulted in increased yield at harvest, increase in final leaf number per plant and a slight delay in maturity compared with the dry treatment).

SALTER, P. J. and HAWORTH, F. (1961). The available water capacity of a sandy loam soil. I. A critical comparison of methods of determining the moisture content of soil at field capacity and at the permanent wilting percentage. *J. Soil Sci.*, **12**, 326-34.

(A comparison has been made of methods of determining the upper and lower limits of the available water in field soil. The methods preferred for critical work were the measurement of field capacity on samples taken directly from the soil after rain or irrigation, when drainage had almost ceased, and the measurement of the permanent wilting percentage on undisturbed cores of soil).

SALTER, P. J. and HAWORTH, F. (1961). The available water capacity of a sandy loam soil. II. The effects of farmyard manure and different primary cultivations. *J. Soil Sci.*, **12**, 335-42.

(The effects of annual applications of farmyard manure and of different cultivation treatments for a six-year period on the available water capacity of a sandy loam soil have been measured. The farmyard manure applications led to a significant increase in the available water capacity of the soil; the cultivation treatments influenced the available water capacity to a lesser extent).

TOMLINSON, J. A. (1961). The control of watercress crook root disease by the use of zinc sulphate. *N.F.U. Watercress Branch News Sheet* (Supplement).

(Gives a description of an apparatus for applying small quantities of zinc sulphate at a constant rate to the water supplying cress beds).

WHEATLEY, G. A. (1961). Some properties of powders used in pesticides. *Powders in industry*. S.C.I. Monograph No. 14. London: Society of Chemical Industry. 1961, 307-22.

WHEATLEY, G. A., WRIGHT, D. W. and HARDMAN, J. A. (1960). The re-treatment of soils with dieldrin for the control of carrot fly. *Plant Pathology*, **9**, 146-8.

(Experiments have shown that the half-life of dieldrin in fen and mineral soils in the U.K. is not less than four years. It is probable, therefore, that residues of this insecticide will accumulate to undesirable levels if soil is re-treated at the rates originally recommended for the control of carrot fly on these soils. Reduced amounts of dieldrin for use when re-treating soils are tabulated).

WINTER, E. J. (1961). Irrigation. *E.D.A. Rural Electrification Conference 1961*, Part 1, H.1-6.

(A review of irrigation methods, costs, and returns to be expected, with examples from the irrigation of vegetables in the U.K. Special mention is made of the possible uses of electricity for this purpose).

THE JOURNAL OF HORTICULTURAL SCIENCE

The Journal of Horticultural Science exists to publish results of research on fruit and other perennial crops, vegetables and flowers. The Publication Committee welcome papers from both temperate and tropical countries describing original investigations of interest to those engaged in scientific research and the practice of horticulture. Papers for publication and all communications should be sent to the Editors, East Malling Research Station, Maidstone, Kent.

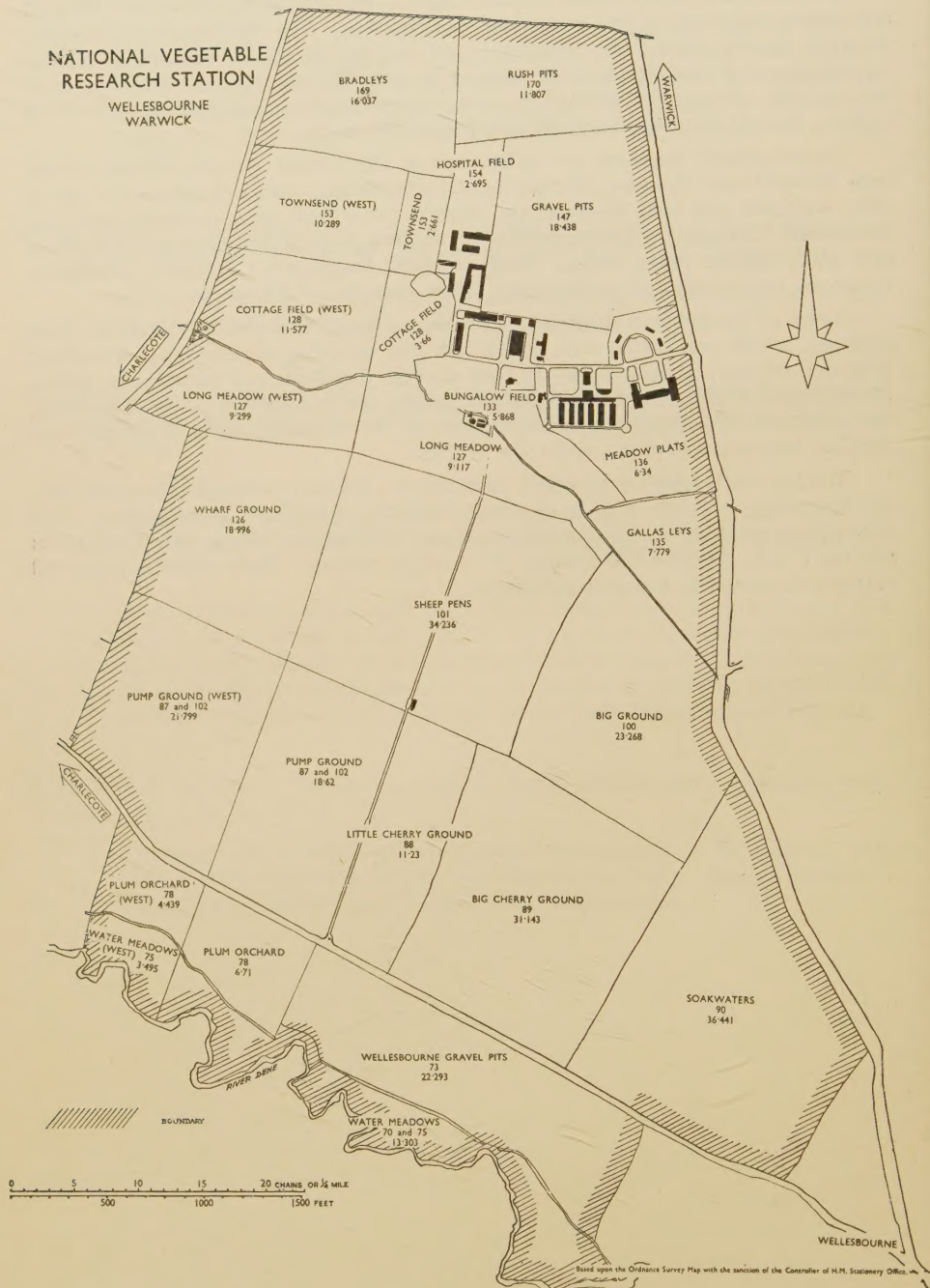
Papers already accepted for publication in the current Volume 37 (1962) have been received from the main Horticultural Research Institutes in England, as well as from Australia and New Zealand, and contributions from other countries are being considered. As usual, a diverse selection of crops is covered, including spring cabbage and peas; apples, pears, plums, black currants, raspberries and vines; glasshouse tomatoes, cucumbers and mushrooms; tulips, carnations and stocks.

Some of the subjects dealt with in accepted papers are the nutrition of spring cabbage, apples and bulbs, and the growth and cropping of glasshouse tomatoes; irrigation of peas; various factors in fruit storage; two studies of variation in apples, physiological investigations on apples and grapes, the propagation of black currants; the reduction of saprophytic contaminants in the carnation cultured-cutting test, *Stereum purpureum* in plums and apple viruses.

The Journal is issued in quarterly parts and is published by Headley Brothers Ltd., 109 Kingsway, London, W.C.2, to whom intending subscribers should apply. The subscription rates for the current volume are 60 shillings per volume (rate for Canada and the U.S.A. \$8.50) or 20 shillings for a single number. Back numbers of several volumes are available from the publishers.

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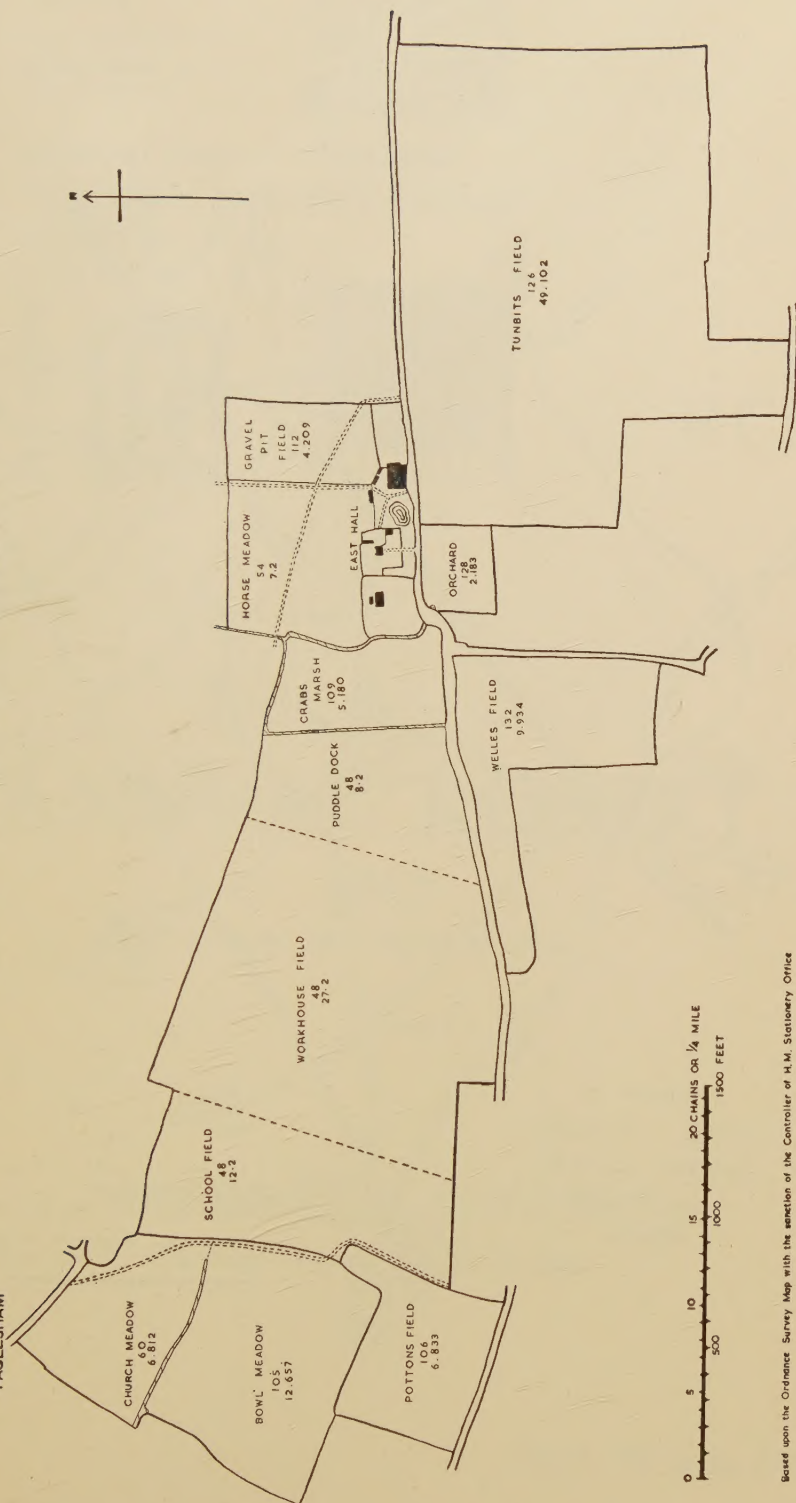
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